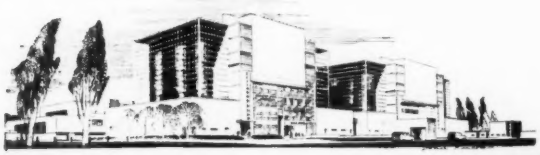
Nuclear Power

BIG BRADWELL COLOUR INSERT

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

ymbol of a Greater Britain

Construction of the new nuclear power station at Bradwell, Essex, for the Central Electricity Authority is the responsibility of The Nuclear Power Plant Company Limited; the guaranteed output will be 300 megawatts. N.P.P.C. combines the resources of eight specialist companies whose individual skills are planned and co-ordinated into a unified team capable of undertaking the construction of complete nuclear power stations throughout the world.



ght Companies make

NPPC

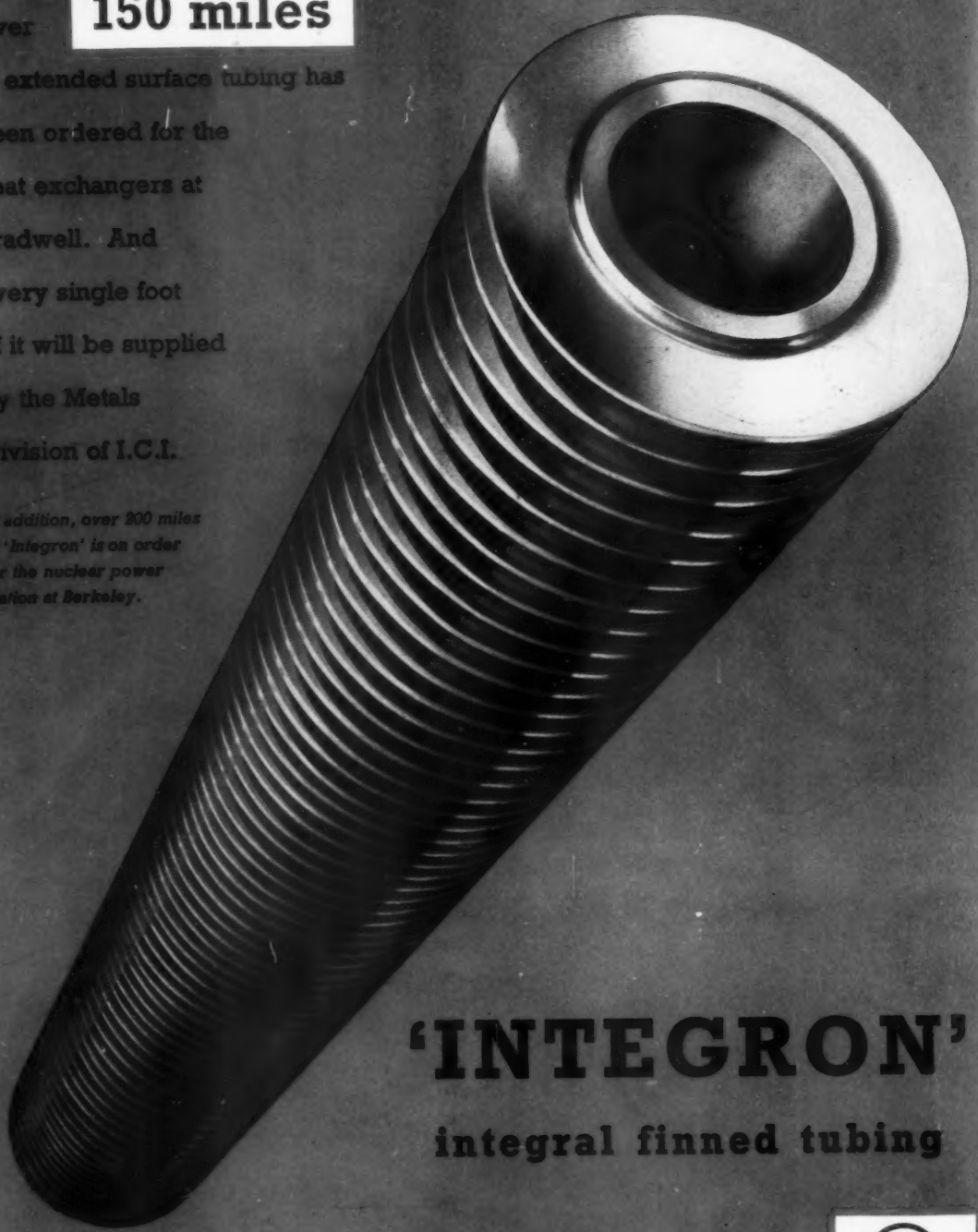
THE NUCLEAR POWER PLANT COMPANY LIMITED

OCTOBER 1957 3/6

Over **150 miles**

of extended surface tubing has been ordered for the heat exchangers at Bradwell. And every single foot of it will be supplied by the Metals Division of I.C.I.

In addition, over 200 miles of 'Integron' is on order for the nuclear power Station at Berkeley.



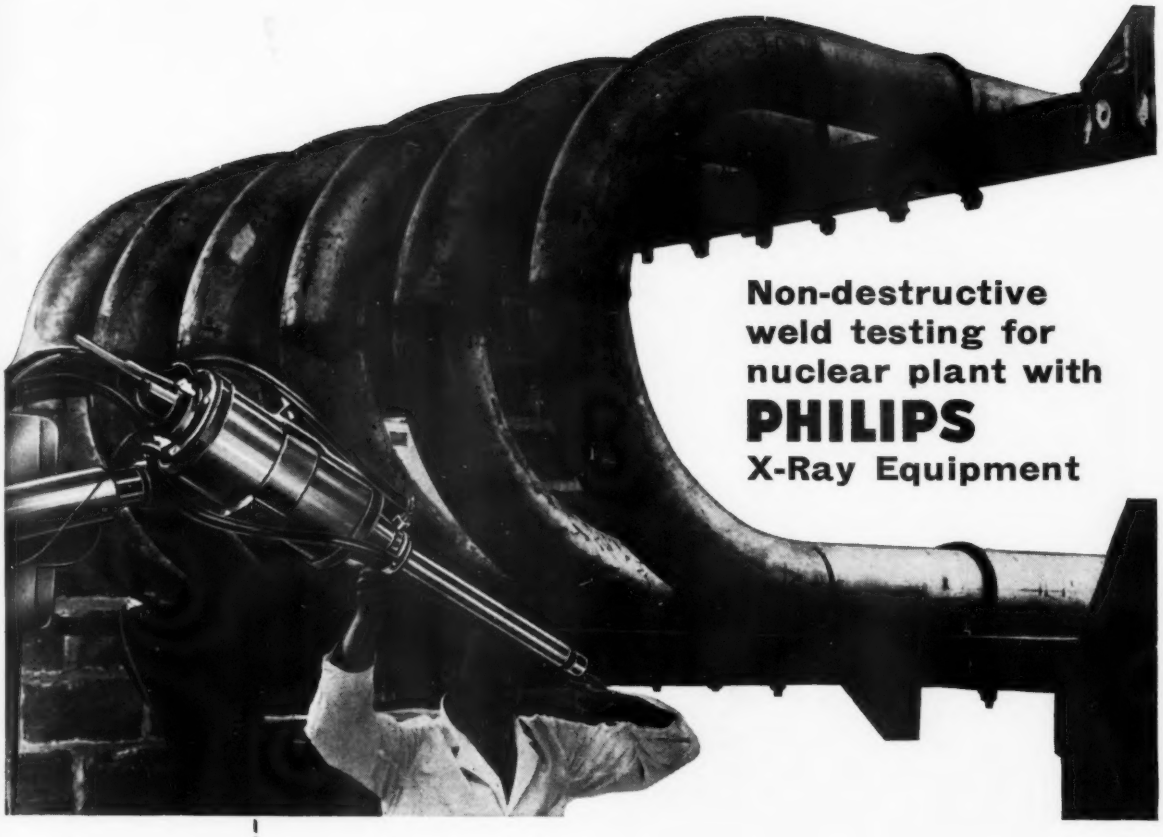
'INTEGRON'

integral finned tubing

First in Nuclear Metals

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

ICI METALS DIVISION



Non-destructive weld testing for nuclear plant with PHILIPS X-Ray Equipment

Philips portable Macrotank 'D' X-Ray Units are now in use on the inspection of site welding at Dounreay

Welded joints in this stainless steel pipework for liquid metal heat exchangers are here being inspected to extremely high standards with Philips X-Ray equipment. The heat exchangers, together with all liquid metal circuits, and principal vessels, are under construction by John Thompson Limited, Wolverhampton, for the U.K. Atomic Energy Authority's first full-scale breeder station at Dounreay, Caithness.

Philips manufacture a wide range of X-Ray equipment suitable for non-destructive weld testing on nuclear reactor installations.

Please write for further details

PHILIPS ELECTRICAL LTD

RESEARCH & CONTROL INSTRUMENTS DIVISION

Century House · Shaftesbury Avenue · London · W.C.2

Telephone: GERrard 7777

(PRC0233)

Progress must have a past...

The Morgan Crucible Company's past started a hundred years ago — in the Morgan Brothers' warehouse in Jewin Crescent in London. Progress since then has been on such a scale that today every industry in the land makes use, either directly or indirectly, of Morgans' products and components. With that sort of experience behind them, no wonder Morgans' chemists, engineers, metallurgists, physicists, technologists and craftsmen are facing the future with such confidence — and indeed are already playing an important part in the widening fields of electronic and nuclear engineering.

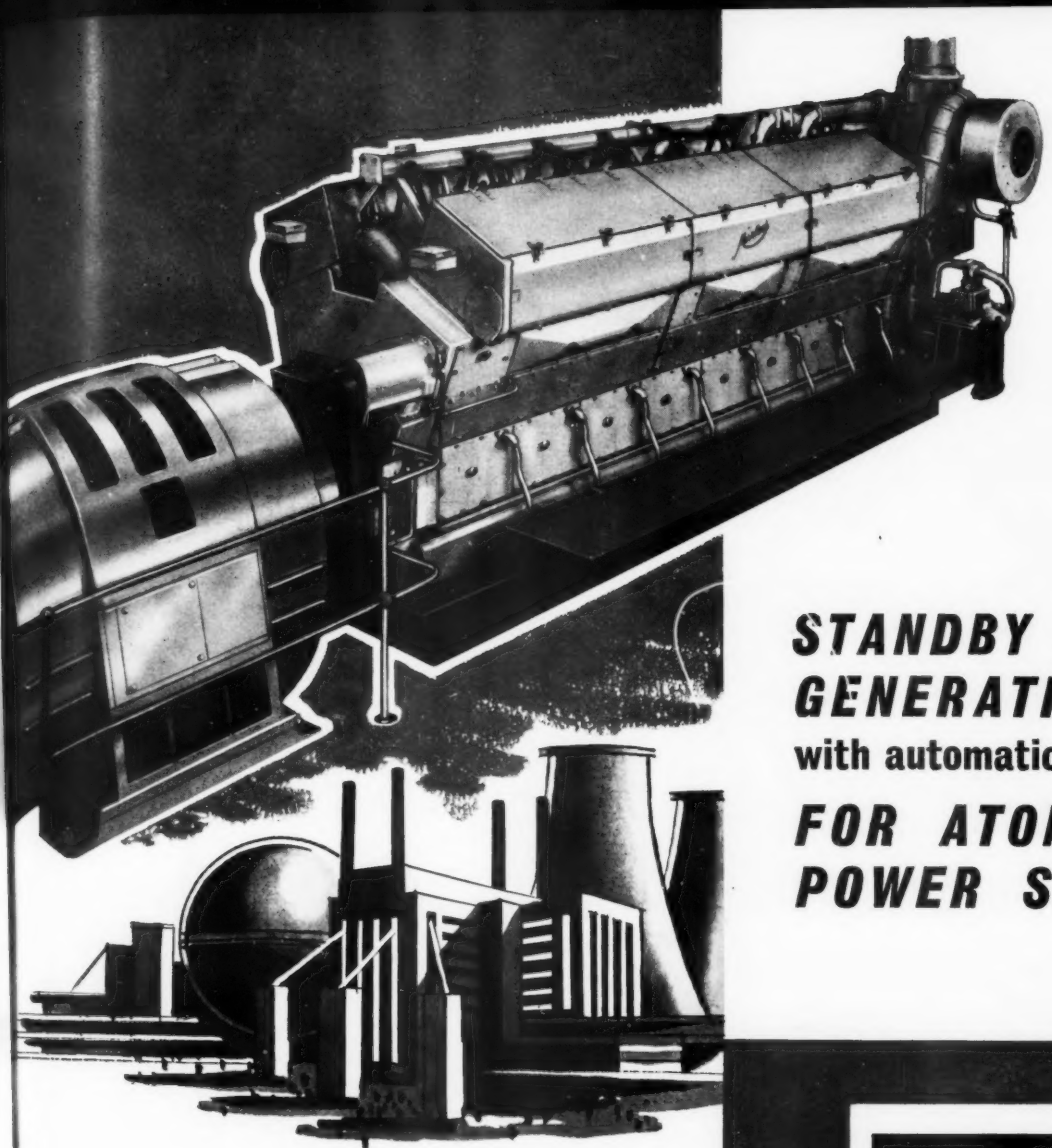
MORGANS

CARBON AND GRAPHITE-ELECTRICAL CHEMICAL AND MECHANICAL: CRUCIBLES, FURNACES, REFRACTORIES: RADIO PARTS, SINTERED METAL PRODUCTS AND ELECTRIC FURNACE ELEMENTS.

THE MORGAN CRUCIBLE COMPANY LIMITED, BATTERSEA CHURCH ROAD, LONDON, S.W.11

Telephone: BAT. 8822

MCC 126/A



STANDBY GENERATING SETS
with automatic starting

FOR ATOMIC POWER STATIONS

Within a few seconds of receiving the starting signal and without manual attendance, these Mirrlees oil-engine sets will carry full load, providing a reliable auxiliary and standby supply for atomic power stations and other installations where it is essential to forestall breakdowns and serious loss due to cessation of mains power supply. The Mirrlees J and JV Types of engine cover a comprehensive series including 3, 4, 5, 6 and 8-cylinder in-line engines and 12 and 16-cylinder vee-form engines. All can be offered in naturally aspirated or turbocharged form, the latter with or without air aftercoolers.

Mirrlees diesels

The power range extends from the 210 BHP J3 three-cylinder naturally aspirated up to the 2272 BHP JVSS 16 sixteen-cylinder turbocharged engine with air aftercooler.

MIRRLEES, BICKERTON AND DAY LIMITED
HAZEL GROVE · STOCKPORT · CHESHIRE

A member of the BRUSH Group

Telephone: Stepping Hill 3841 (14 lines) *Telegrams:* "Mirrlees Telex, Manchester"

The sealed building for DIDO

The sealed building for the Dido experimental reactor at Harwell is intended to confine the atmosphere around the reactor in the event of an accident. Access of personnel and vehicles is by air locks, and the floor has a continuous steel membrane embedded in concrete and joined to the shell, forming an effective seal.

The design was based on accepted practice as laid down in B.S. 1500 "Fusion-Welded Pressure Vessels". But much of the work was outside standard design codes and practices, so the United Kingdom Atomic Energy Authority called on the experience of Whessoe Limited in making large site-built vessels.

In the resulting contract with the Ministry of Works, welding and inspection procedures were rigidly controlled to exclude the possibility of initial defects in the welded seams. Lloyd's Register of Shipping advised the Chief Engineer of the Ministry on the design, inspection and testing. Only first-class welders were allowed to work on the project, and each was further tested to ensure a high standard of welding. All welds were subjected to 100% radiography, and Kodak 'Industrex' X-ray Film Type D was used exclusively.

Kodak **INDUSTRIAL X-RAY FILMS**

first choice of inspection engineers—everywhere

Send for

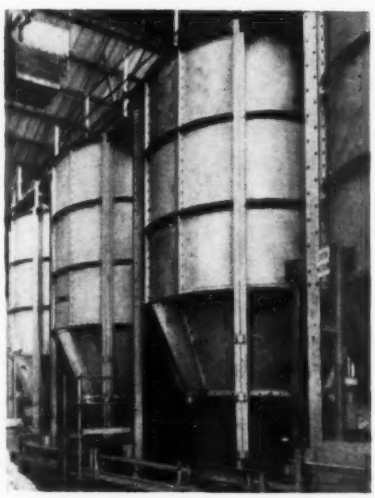
* *a 70-page catalogue giving details of the latest radiographic equipment and materials.*
* *a 24-page booklet, "Photography at Work", giving practical examples of the use of photography in industry.*
* *Information on any specific technique employed in industrial radiography or photography.*

Kodak Limited, Industrial Sales Division,
Kodak House, Kingsway,
London, W.C.2.

'Kodak' is a registered trade-mark

call in the specialists

Specialists for 30 years in the manufacture of mechanical materials handling aids for every industry, Paterson Hughes produce the finest complete schemes and equipment to suit any application. A satisfactory materials handling scheme, designed to fulfil specific requirements effects considerable economies of labour and space. For the major step to higher production, consult

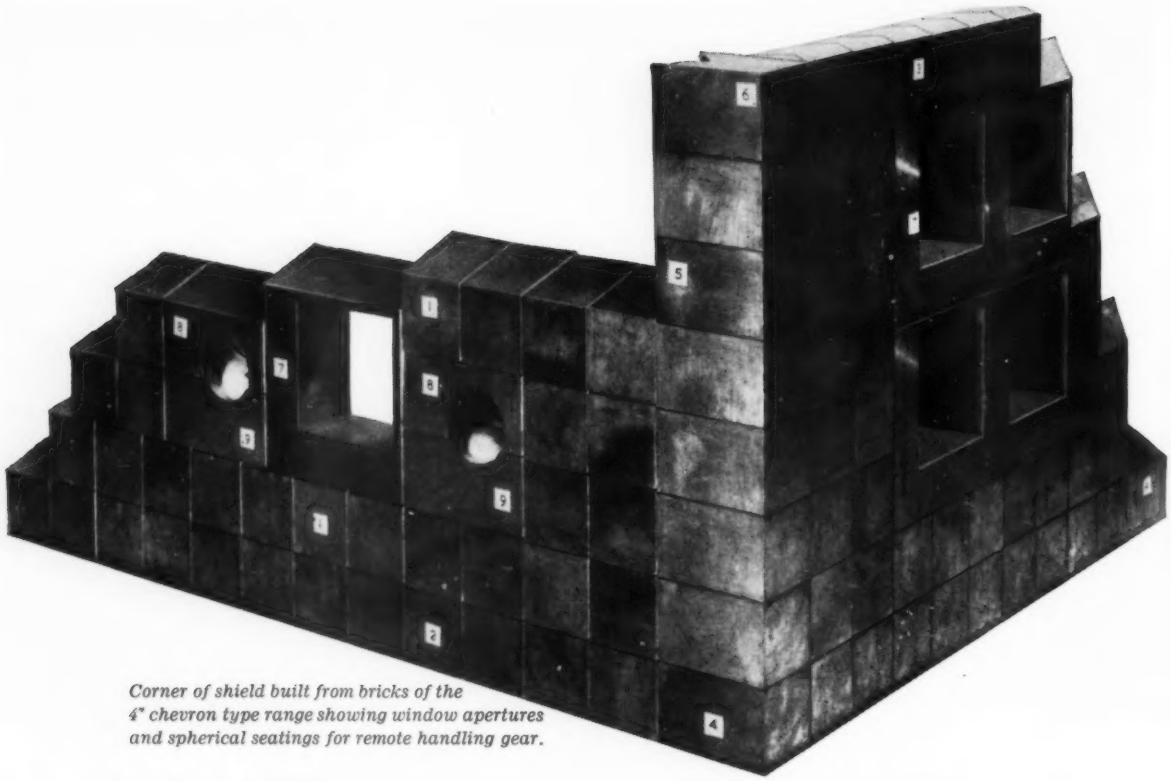


PATERSON HUGHES
ENGINEERING COMPANY LIMITED

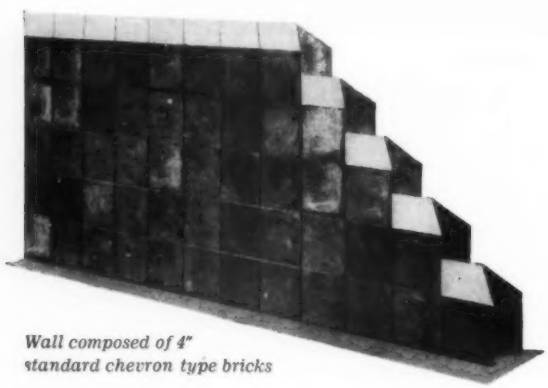
MECHANICAL HANDLING ENGINEERS AND CRANE MAKERS

WYNDFORD WORKS · MARYHILL · GLASGOW · TEL MARYHILL 2172-4
BEDFORD HOUSE · BEDFORD ST · LONDON · WC2 · TEL TEMPLE BAR 7274-6
3 HIGHFIELD RD · EDGBASTON · BIRMINGHAM · TEL EDGBASTON 2957-8
8 CHATHAM ST · PICCADILLY · MANCHESTER · TEL CENTRAL 6623
PATERSON HUGHES ENGINEERING SA (PTY) LTD · PO BOX 811 JOHANNESBURG

P.4334
A5



Corner of shield built from bricks of the 4" chevron type range showing window apertures and spherical seatings for remote handling gear.



Wall composed of 4" standard chevron type bricks

LEAD SHIELDING

Some of the lead bricks we supplied to the United Kingdom Atomic Energy Authority are shown in these photographs. The people to consult about the production of special shapes for shielding are Associated Lead.

ASSOCIATED LEAD

MANUFACTURERS LIMITED

IBEX HOUSE, MINORIES, LONDON, E.C.3.
CRESCENT HOUSE, NEWCASTLE
LEAD WORKS LANE, CHESTER

Export enquiries to: THE ASSOCIATED LEAD MANUFACTURERS EXPORT CO. LTD., IBEX HOUSE, MINORIES, LONDON, E.C.3

WEIR

AUXILIARIES for Nuclear Power Plant

The reliability and high efficiency in design materials and performance associated with Weir Auxiliaries for steam installations are now being applied to Weir equipment for Nuclear Power plant.

Research, development, design and manufacture of the highest standard, maintain Weir leadership in the auxiliary field, whatever the source of energy.

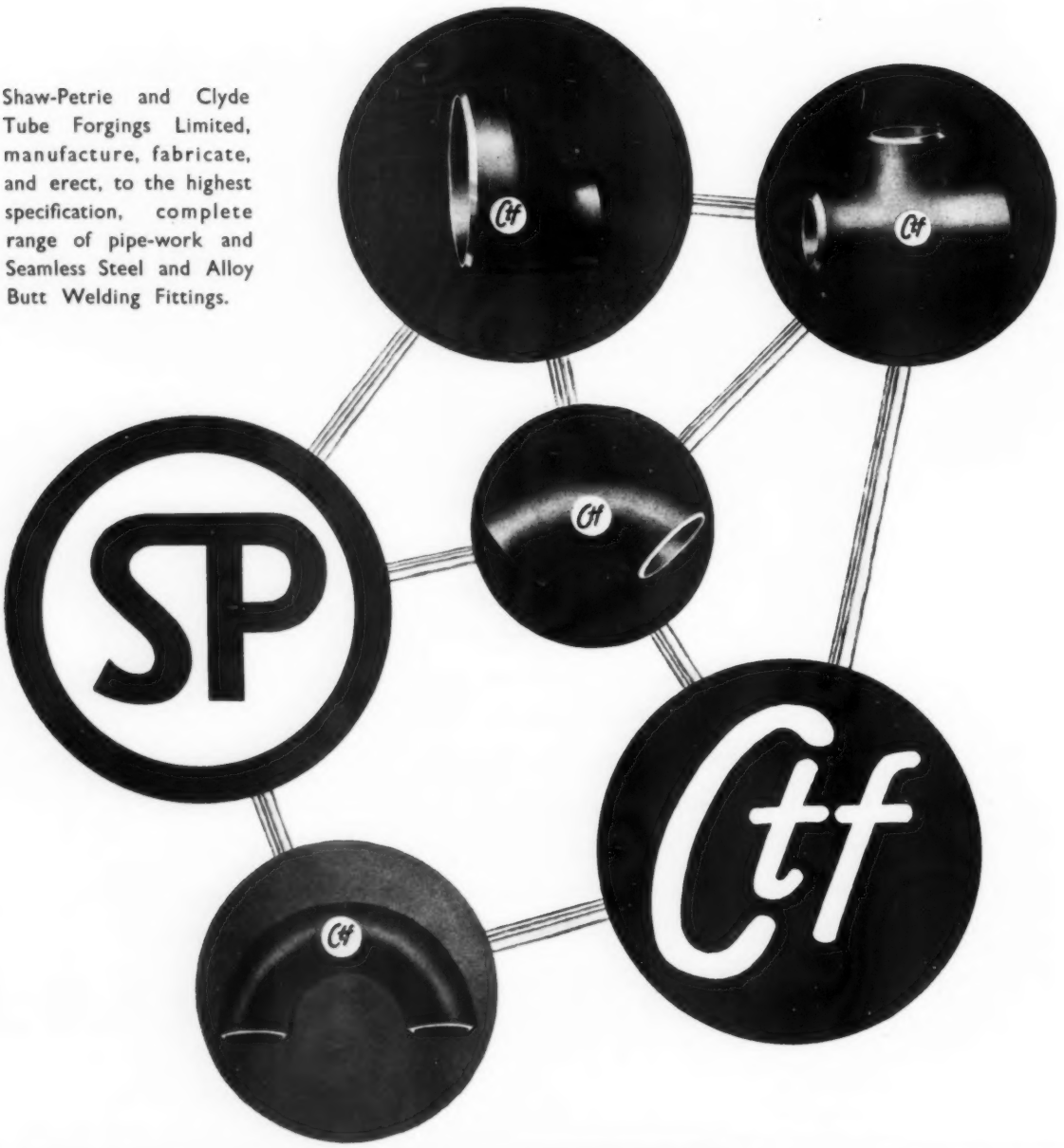
In the rapidly changing field of power reactor technology, we can give expert assistance on such equipment, and we invite consultation on all questions relating to the design and manufacture of Pumps, Valves, Heat Exchangers and other Auxiliaries for Nuclear Power circuits.

G. & J. WEIR LTD.
CATHCART : GLASGOW

MANUFACTURERS OF POWER PLANT AUXILIARIES FOR LAND AND MARINE DUTIES

Pipe installations for the Nuclear Engineer

Shaw-Petrie and Clyde Tube Forgings Limited, manufacture, fabricate, and erect, to the highest specification, complete range of pipe-work and Seamless Steel and Alloy Butt Welding Fittings.



SHAW-PETRIE LIMITED | **CLYDE TUBE FORGINGS LTD**

NORTH HILLINGTON · GLASGOW SW2 · TELEPHONE HALFWAY 5551-6

LONDON OFFICE 157 VICTORIA ST. SW1
TELEPHONE TATE GALLERY 9325-6
AND AT SOUTH SHIELDS, LIVERPOOL AND BELFAST

OVERSEAS
CANADIAN CLYDE TUBE FORGINGS
P.O. BOX 278 WESTON ONTARIO

New Zealand, East West Central and South Africa, Australia, Barbados, British Guiana, Jamaica, Trinidad, Italy Spain, Mexico and Venezuela, Belgium Holland, Norway Sweden and Finland

CLYDE TUBE FORGINGS OF AMERICA
PORTLAND OREGON U.S.A.

In the construction of the Fast Breeder Reactor at the atomic power station at Dounreay, 'ROCKSIL' is the chosen insulator. 'ROCKSIL' is being used for the insulation of the main and auxiliary equipment including heat exchangers, tanks and piping. The installation is being carried out by William Kenyon & Sons Limited, who obtained the contract.

Dounreay uses ROCKSIL regd.

ROCK WOOL INSULATION

'ROCKSIL' is the latest synthetic inorganic fibre, produced in Britain from natural Scottish Rock. The basis of all Rocksil Insulation is a white fleecy wool—a low-density, resilient mass of long siliceous fibres consisting of up to 95% of air by volume. Besides being a highly efficient insulator throughout all temperature ranges up to 1400°F., 'ROCKSIL' is fire resistant, chemically inert and sulphur-free, non-hygroscopic, odourless and rot-proof; it does not contain glass or slag. It is available in a variety of forms, such as loose wool or fabricated products, to suit every application requirement.

CAPE

Write for literature and all further details to the manufacturers:

THE CAPE ASBESTOS COMPANY LIMITED, 114 & 116, Park Street, London, W.1. Tel: Grosvenor 6022.

and at **Glasgow:** 217, Bothwell Street, Glasgow. Telephone: Central 2175.
Manchester: National Buildings, St. Mary's Parsonage, Manchester, 3. Telephone: Deansgate 6016-7-8
Birmingham: 11, Waterloo Street, Birmingham, 2. Telephone: Midland 6565-6-7.

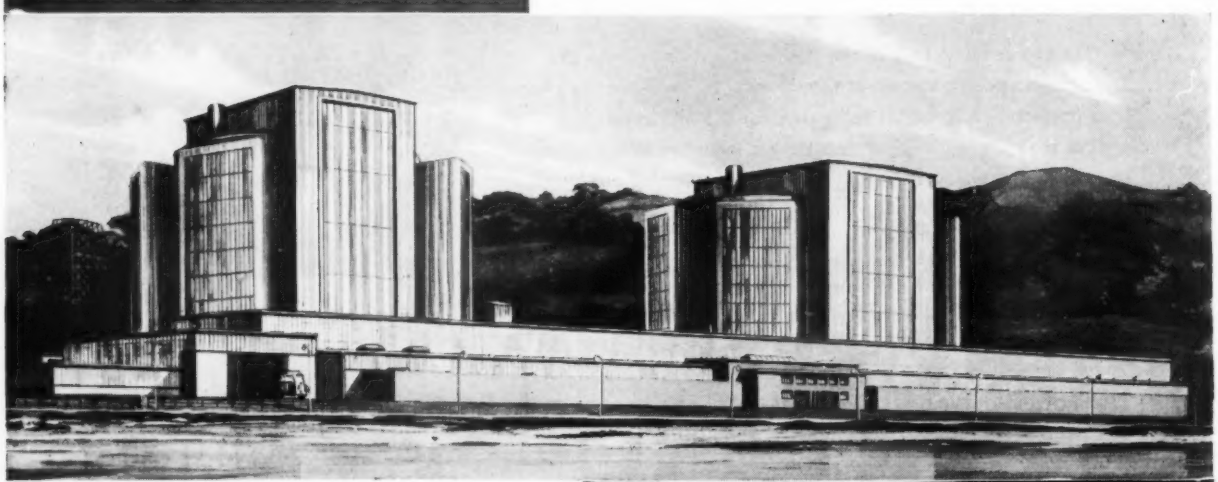
also distributed by: **WILLIAM KENYON & SONS LTD.,** Dukinfield, Cheshire. Telephone: Ashton-under-Lyne 1614.

TA10362

POWELL DUFFRYN Carbon Products Limited

Manufacturers of
Carbon and Graphite materials
Designers and constructors
of chemical plant
and equipment
in Carbon and Graphite

MACHINISTS OF NUCLEAR GRAPHITE FOR ATOMIC REACTORS

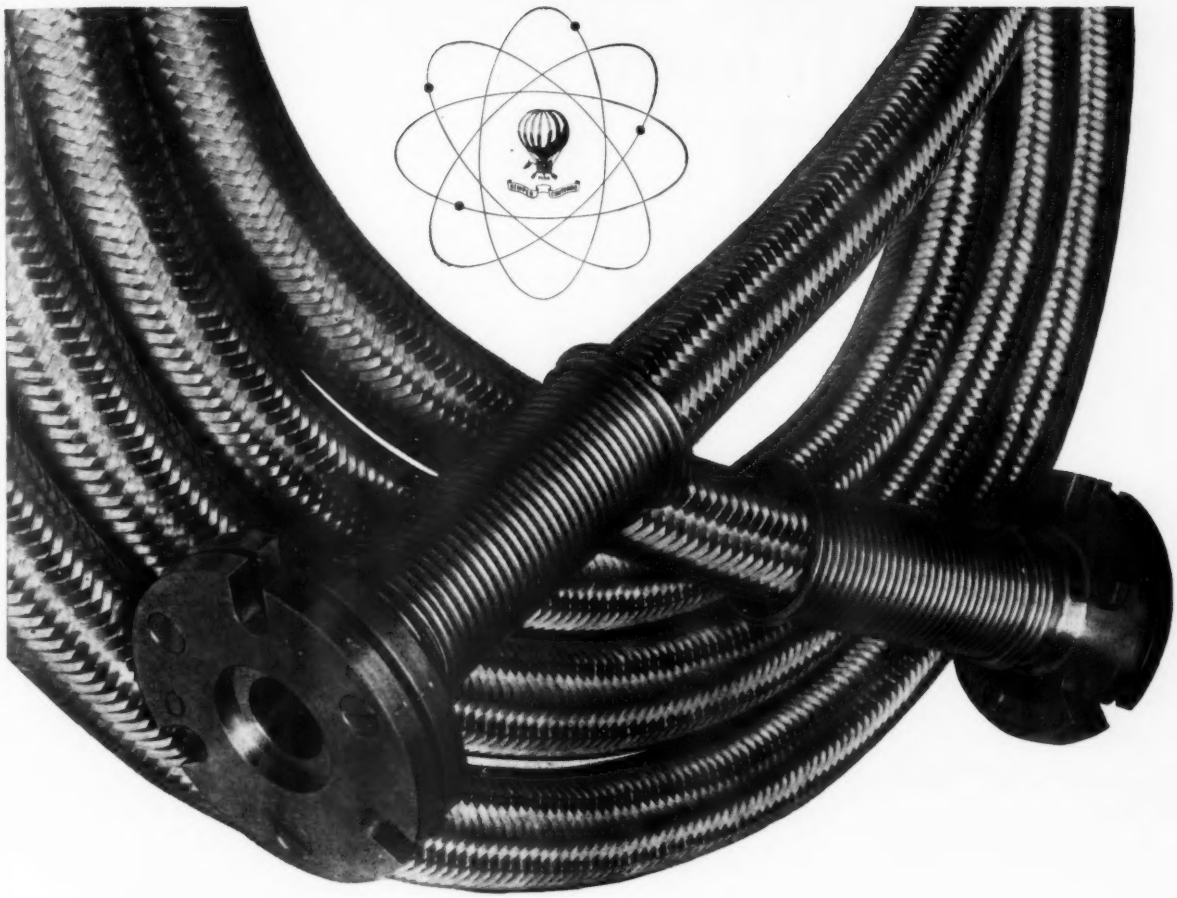


Approximately 8,000 tons of Nuclear Graphite blocks and components will be machined for the two reactors of the world's largest Atomic Power Station to be built by the

GENERAL ELECTRIC COMPANY LTD.
for the South of Scotland Electricity Board

POWELL DUFFRYN CARBON PRODUCTS LTD

SPRINGFIELD ROAD HAYES MIDDLESEX
TELEPHONE HAYES 3994 TELEGRAMS CARBONACES HAYES



AVICA equipment for nuclear engineering

Stainless Steel FLEXIBLE PIPE ASSEMBLIES
For conveying gases and corrosive fluids at extremes of high and low temperature. Available up to 4 in. diameter.

BELLOWS and BELLOWS ASSEMBLIES
For use in gas and fluid ducting systems for control of expansion or contraction, and to allow for misalignment and duct movement. Other applications include shaft seals and glands. Available in stainless steel and other metals.

High Pressure SWIVEL PIPE COUPLINGS
and Flexible Tubes for hydraulic circuits operating at pressures up to 4000 p.s.i.

ELECTRICAL CONDUIT
and Wiring Assemblies and Support Clips.

TECHNICAL DATA IS AVAILABLE ON REQUEST

New industries draw on the experience of older industries—and Nuclear Engineering is no exception.
At AVICA we find our specialized knowledge of flexible pipe and coupling design as applicable to the Nuclear field as it has been for so long to older branches of engineering. For reliability and accuracy with AVICA have always been regarded as prime qualities.
As a result, AVICA equipment is available for use in Nuclear Engineering with the same high standards of design and quality which apply in aircraft, marine and other specialized branches of industry. As in every other field of engineering, the maxim is consult AVICA if you have a flexible pipe assembly problem.
AVICA PRODUCTS are used by the U.K.A.E.A. and throughout the Nuclear Engineering field.

AVICA EQUIPMENT LIMITED

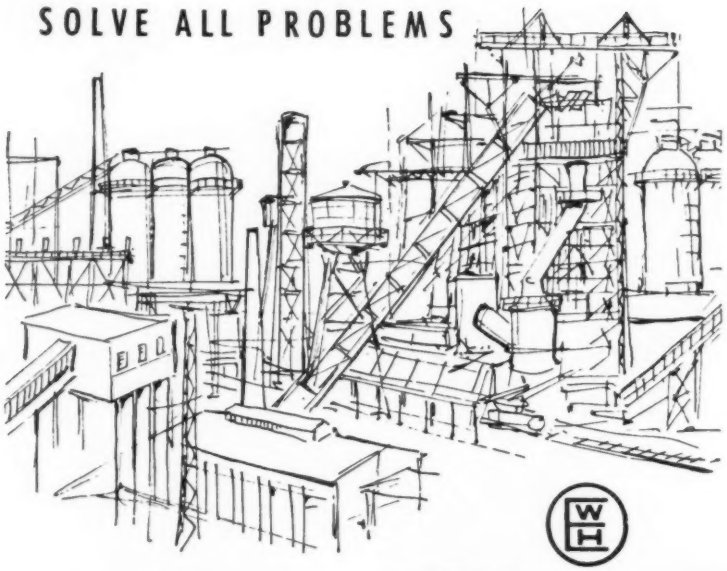
Mark Road, Hemel Hempstead, Herts. Tel: BOXmoor 4711 (6 lines)

THE WORLD-WIDE-FAMOUS

ERHARD
VALVES

known for their Design, Precision and Quality for more than 80 years.

SOLVE ALL PROBLEMS



JOHANNES ERHARD H. WALDENMAIER ERBEN
Süddeutsche Armaturenfabrik, Heidenheim / Brenz · Germany
Telephone 3881 Cable · Erhardarmaturen

For all information write to:

The Sole Agents for the United Kingdom

A.K. STARCK'S CO. LTD. 22, Chancery Lane London W.C. 2

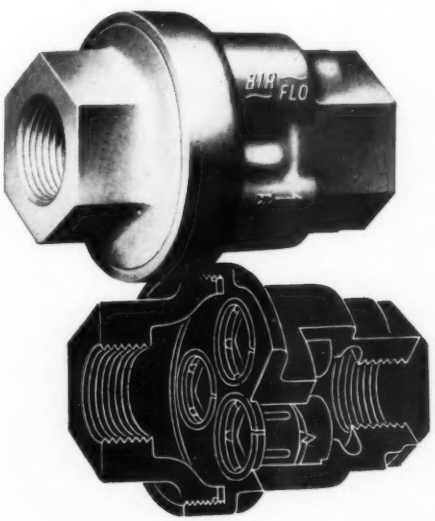
Telephone Holborn 2966 Cable: Akstar London

Birflo controls

for positive and precise regulation of water, light oil or air flow

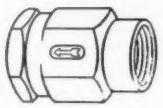
Multi-Constaflo

CONTROL

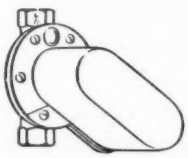


for water flow rates from 7-18 Imperial g.p.m.

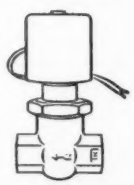
The Multi-Constaflo Control is an entirely new concept of how to control and to maintain one set rate of fluid flow regardless of variable inlet pressures. It is not just another retarding or pressure reducing device, but a true and accurate means of discharging a specific flow rate. The Multi-Constaflo Control makes it unnecessary to pay for inadequate and expensive pressure reducing and throttling devices that strangle or suppress the supply pressure, and which do not automatically adjust themselves to all the wide range of variable pressures that exist in the water distributions systems of to-day.
The Multi-Constaflo is one of seven Birflo controls, each one designed to overcome a particular flow problem.



CONSTAFLO
A flow volume control to deliver one set flow, regardless of variable inlet pressures.



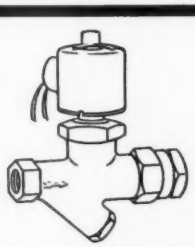
TRUFLO
A control to protect equipment when flow is below a desired minimum; or above a desired maximum.



FLOMAX
An electrically operated valve for controlling On and Off flow of liquids.

FLOMITE
A direct action solenoid valve for small flow volume control.

STRAITFLO
A straight line strainer, installed in the supply, having the entire strainer area within the flow way itself.



FLOMETRIC
An electrically operated valve, with flow volume control.

Fully informative leaflets covering the whole range of "BIRFLO" controls are available on request.

product of **BIRFIELD** **GROUP** experience and resources

Made under licence from the Hays Manufacturing Company, Twelfth and Liberty Street, Erie 6, P.A.

Enquiries to: **BIRFIELD INDUSTRIES LIMITED** · STRATFORD HOUSE · LONDON W.1

* tailor-made to each job!

*** MULTIRAIL**
fabricated steel handrail standards

MULTIRAIL fabricated steel handrail standards have proved to be as rigid as the solid forged type, with the advantages of four ferrules enabling vacant ferrules to be used in carrying power lines, air and gas pipes, etc.

"SAFETREAD" FLOORING IS

welded for extra strength

Tailor-made and not just cut to fit, 'Safetread' flooring is no dearer to specify than ordinary steel flooring, but provides maximum strength with minimum of materials; non-skid surface; 82% light and air penetration; a neat-fitting, clean appearance.

* **SAFETREAD** WELDED FLOORING

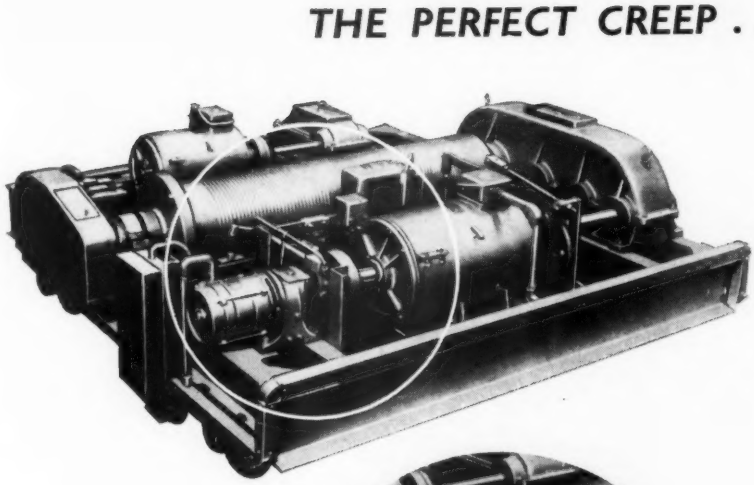
Write for detailed literature to:—

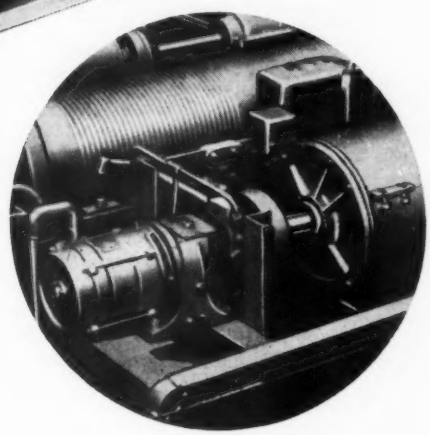
Allan Kennedy & CO. LTD.

MARITIME STREET · STOCKTON-ON-TEES

Tel: Stockton 67706 & 67716. Grams: Grating, Stockton-on-Tees. Also at 207 Victoria Street, London, S.W.1

THE PERFECT CREEP . . .





Registered U.K. Patent No. 678466

Slomax Creep-Speed Control

This system was developed to meet the need for a controlled creeping speed for all motions of cranes on A.C. supply where precise slow speeds are required.

The success of this well-tried system, proved under arduous conditions, lies in its extreme simplicity.

The device is entirely automatic and fool-proof.
The main motor is not energised when the creeping speed is in operation.

The operating circuits being electrically inter-locked it is impossible for the main motor and the Slomax motor to operate simultaneously.

Slomax control permits an unlimited ratio between creeping and normal speeds, and whilst ten to one is usual, a ratio of fifty to one is not uncommon for specialised duties.

A further advantage is that where precise creeping speeds are required for specialised operations, the Slomax control will ensure a predetermined creeping speed, irrespective of the load on the hook.

During the past 2 years "Slomax" Control has been supplied to the following customers.

Admiralty.
Central Electricity Authority.
Crown Agents for the Colonies.
The Ministry of Works.
United Kingdom Atomic Energy Authority.

Brayshaw Furnaces and Tools Ltd.
Copper and Alloys Ltd.
Earle Bourne and Co. Ltd.
Electric Construction Co. Ltd.
Ferguson Pailin Ltd.
Fraser & Chalmers Engineering Works (G.E.C. Ltd.).
The General Electric Co. Ltd.
Hall Brothers.
Imperial Chemical Industries Ltd.
Richard Johnson and Nephew Ltd.
Lever Bros. (Port Sunlight) Ltd.
Mumford Medland Ltd.
The Marshall Equipment Co. Inc.
John Needham and Sons Ltd.
Kenneth Ray Ltd.
Serck Radiators Ltd.
John Summers and Sons Ltd.
Stone-Wallwork Ltd.
J. Edwin Wall and Son Ltd.

THE WHARTON CRANE & HOIST CO. LTD.

REDDISH STOCKPORT ENGLAND

Phone: Heaton Moor 2227. Grams: "Gallant, Manchester." Code: Western-Union

London: Lincoln House, 296/302 High Holborn, London, W.C.1. Telephone: Chancery 7911

Scotland: Fisher, Baxter & Co., 140 West George Street, Glasgow, C.2.	Phone: Douglas 1061-2-3	Grams: 'Fluorspar' Glasgow
Midlands: A. R. Holland & Son, 89 Cornwall Street, Birmingham, 3.	Phone: Central 1457	Grams: Central 1457, Birmingham
South West: R. C. Collins, 48 Westbourne Road, Penarth, Glamorgan.	Phone: Penarth 1527	Grams: Penarth 1527
Northern Counties: Fisher, Baxter & Co., 140 West George St., Glasgow, C.2.	Phone: Douglas 1061-2-3	Grams: Fluorspar, Glasgow
Northern Ireland: General Engineering Products Ltd., 44-46 Waring Street, Belfast	Belfast Tel: 23743	
Eire or Southern Ireland: Charles Nolan & Co., 2 Parker Hill, L. Rathmines Road.	Phone: Dublin 93510	Grams: Dublin 93510

REPRESENTED IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD.

production engineers

fully equipped for the manufacture of

graphite components.

fabricators of

special equipment *for the*

ATOMIC ENERGY AUTHORITY

If YOU have a special problem, apply to:

Registered Office:
29 ST. JAMES'S ST.,
LONDON, S.W.1.
Tel.: Whitehall 6478

GRAVINER MFG. CO., LTD.,
Fareham Road, Gosport, Hants.
Tel.: Gosport 89175

Aircraft Division:
POYLE MILL WORKS,
COLNBROOK, BUCKS.
Tel.: Colnbrook 2345

also specialists in Industrial Explosion Protection, Airborne Fire Protection Equipment, Thermostats and Overheat Switches.

WELL AWAY

REMOTELY INDICATING OR RECORDING OR CONTROLLING

FUEL CONSUMPTION

Remote Reading Draught Pressure Gauge (REDRA), automatically indicating or recording or adjusting damper to economical draught. Readings can be monitored and recorded at considerable distances.

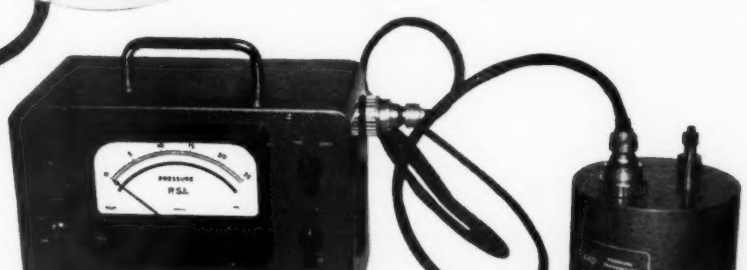
with cover removed

TANK CONTENTS

Remote Reading Tank Contents Gauge (RECON), measures fluid volume by revolutionary method based on Archimedes Principle, providing a new fine degree of accuracy.

Indicating, Monitoring or Recording, as REDRA.

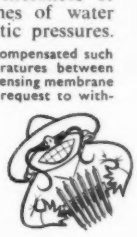
** *The similarity of the Indicator Power Packs for REDRA and RECON facilitates easy servicing.*



PRESSURE DIFFERENCES

Remote Reading Differential Pressure Gauge (REDIFF), measures extremely minute differences of pressure which can be indicated or monitored or recorded. Will indicate Differences of Pressure of a few inches of water BUT withstand high static pressures.

Note: The Transmitter is self-compensated such that it may be used in temperatures between −20°C. to + 70°C. Further, the sensing membrane may be supplied at customer's request to withstand temperatures of 350°C.



SEE US AT THE E.I.A. 10th REGIONAL DISPLAY
Royal Horticultural Society's New Hall,
16-18th October, 1957

WRITE FOR DETAILS OF THESE GAUGES TO:

APPLEBY & IRELAND LIMITED

KEMPSHOTT PARK · BASINGSTOKE · HANTS · Telephone: DUMMER 216 & 383

SINGLE CHANNEL PULSE ANALYSER Type 672

This is a "kick sorter" for the study of pulse height spectra.

INPUT PULSE SENSITIVITY : Accepts positive going pulses 5 to 50 volts amplitude, with rise times of 0.1 to 10 microseconds and decay times up to 100 microseconds.

RESOLUTION TIME : Approximately 2 microseconds.

CHANNEL WIDTH : 0.5, 1.0, 2.0, 5.0, 10.0 or 20.0 volts.

BIAS CONTROL : A helical potentiometer with vernier scale is used to give accurate bias control in conjunction with a 5″ first grade meter.
Facilities are provided for control of the bias voltage remotely for automatic scanning of pulse spectra.

CHANNEL STABILITY : Better than ± 2% of channel width.

I D L

Full details from : **ISOTOPE DEVELOPMENTS LIMITED**

BEENHAM GRANGE, ALDERMASTON WHARF, NR. READING, BERKS. *TELEPHONE : WOOLHAMPTON 45113.*

London Office : 120 Moorgate, London, E.C.2. TELEPHONE : METROPOLITAN 9641.

THE MORGAN *Megistor*

MARK I

A HIGH VALUE, GLASS ENCLOSED RESISTOR,

OF HIGH STABILITY COVERING THE RANGE 10^7 to 10^{14} OHMS.

APPROVED BY THE M.O.S. TO A.E.R.E. SPECIFICATION 390.

Further information may be obtained from :

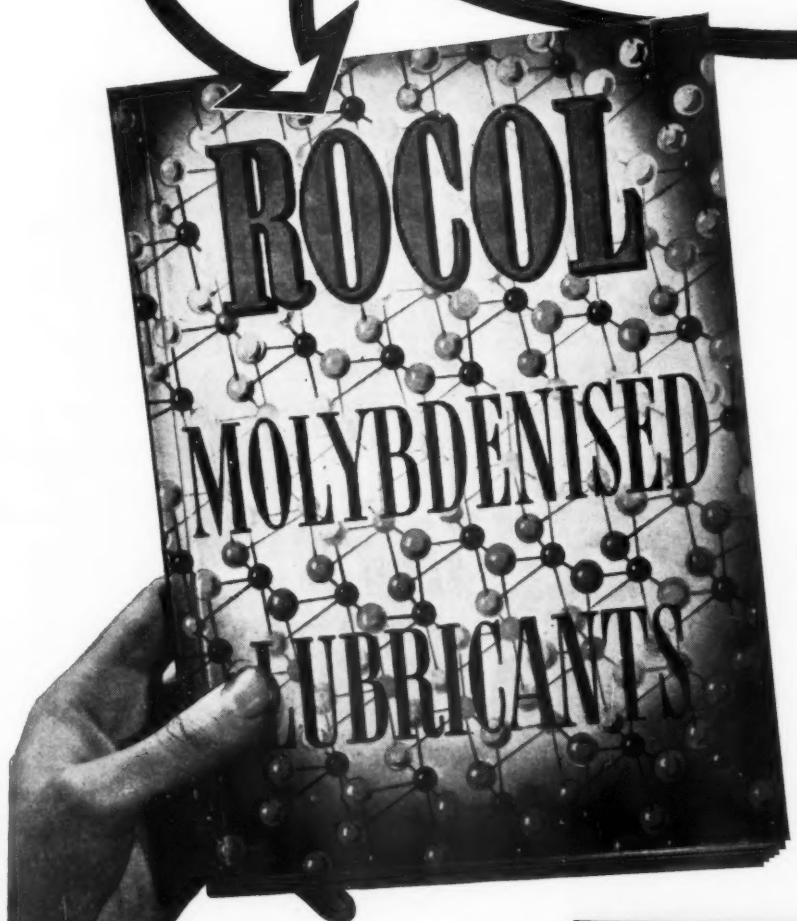
THE MORGAN CRUCIBLE COMPANY LIMITED

'Y' DEPARTMENT, NORTON WORKS, WOODBURY LANE, NORTON, WORCESTER

Telephone : WORCESTER 6691/2 *Telegrams :* CRUCIBLE, WORCESTER

Y.50

Read all about Molybdenised Lubricants in this FREE BOOK



The most comprehensive treatise on Molybdenum Disulphide Lubrication yet published, this book can be of great value to you.

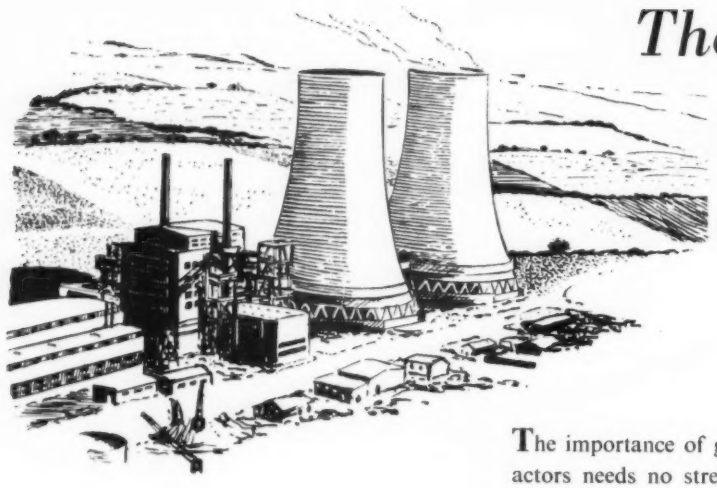
Write today to:

ROCOL LTD

IBEX HOUSE, MINORIES, LONDON, E.C.3. *Telephone: ROYal 4372*

ROCOL HOUSE, SWILLINGTON, Nr. LEEDS *Telephone: Garforth 2261/2*

n.d.h. 3287/A



The Importance of **Graphite**

for Nuclear Power Stations

The importance of graphite moderators in thermal reactors needs no stressing. Production of the graphite from suitable sources involves crushing, for which B.J-D machines are now being specified. The wide range of B.J-D Crushers enables them to be employed for primary, secondary and tertiary stages of reduction.

BJD **Crushers** *in the production of nuclear graphite*

BRITISH JEFFREY-DIAMOND LTD., CRUSHER & INDUSTRIAL DIVISION, 15-17 CAXTON ST., LONDON S.W.1

bjd/3358

Cambridge

ELECTRONIC RECORDER

The Cambridge Model DE Electronic Recorder measures any quantity that can be converted into a small current or voltage. It forms an integral part of complete Cambridge equipments for the measurement of temperature (thermo-couples, radiation pyrometers, resistance thermometers), gas analysis (katharometer bridge method), determination of pH valves, dissolved oxygen in boiler feed water, as well as pure electrical measurements, etc.

Full scale traverse under 2 seconds

Sensitivity better than 0.1% full scale

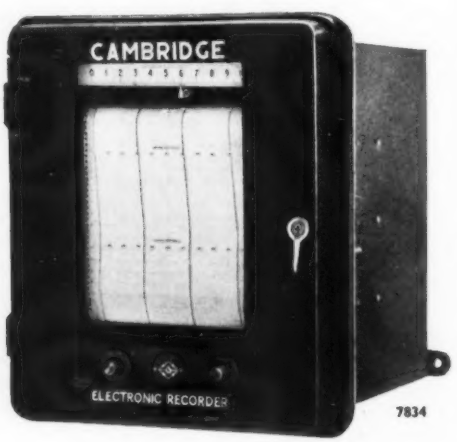
Accuracy better than ±0.5% on all ranges—even down to 1 millivolt full scale, i.e., ±5 microvolts.

Compact, accessible, easy to maintain

High degree of component standardisation

Clean functional design ensures reliability

Write for List No. 186 AP



7834

AUTOMATIC CONTROL

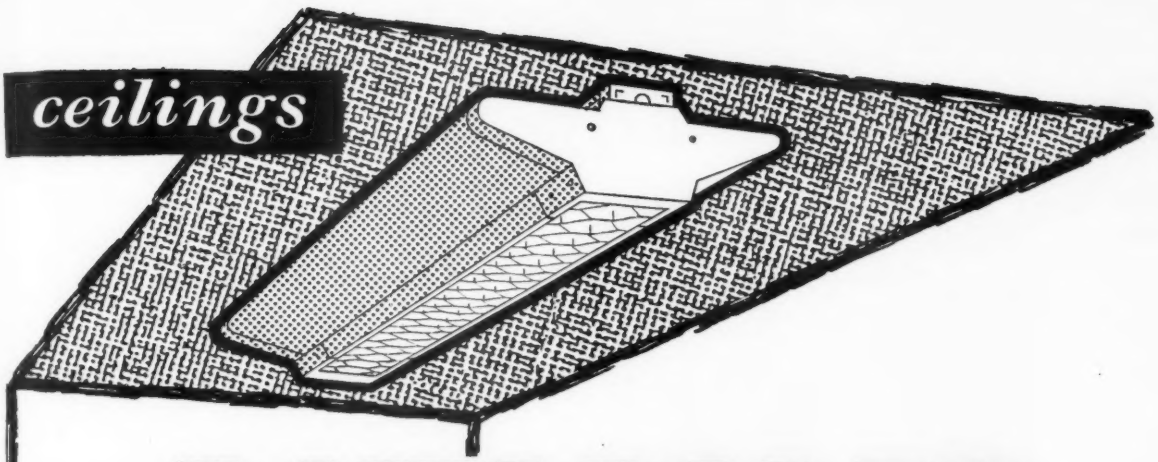
Cambridge electronic recording controllers—single- or multi-point—"on-off", "proportional" or "three-term"—operate multiple switches, slidewires, magslips, pneumatic tranmitters, and other similar control devices.

INTERKAMA

We are exhibiting at "Interkama" Dusseldorf, November 2nd to 10th

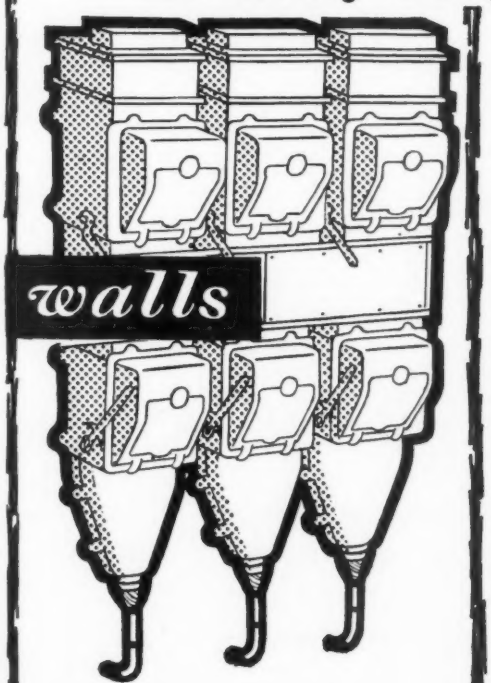
CAMBRIDGE INSTRUMENT COMPANY LTD.

13 GROSVENOR PLACE, LONDON, S.W.1



RAWLBOLTS

For heavy fixing to Ceilings, Walls & Floors



Rawlbolt fixings in concrete, whether in ceilings, walls or floors, are fast and efficient and make real savings in time and money.

Older methods of fixing involve laborious chiselling of holes, grouting in and waiting several days for cement to harden. With Rawlbolts, the job is far simpler and quicker. Drill a hole, insert a Rawlbolt and tighten up. Your equipment is fixed and ready for use immediately.

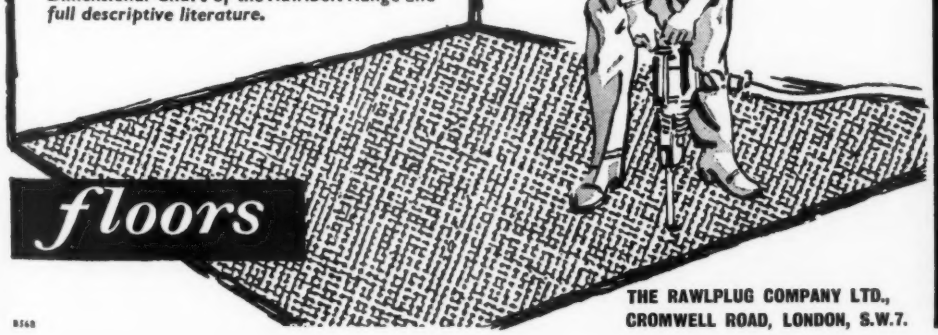
Civil Engineers, Consulting Engineers, Building Contractors, Structural Engineers are large and regular users of Rawlbolts.

TWO TYPES OF RAWLBOLT

LOOSE BOLT TYPE for fixing to floors

BOLT PROJECTING for fixing to walls and ceilings

For more information, please write for Dimensional Chart of the Rawlbolt Range and full descriptive literature.



B568

THE RAWLPLUG COMPANY LTD., CROMWELL ROAD, LONDON, S.W.7.

HEATING ELEMENT *for a high-temperature VACUUM FURNACE with RADIATION SHIELDS*

FABRICATED COMPLETELY FROM

TUNGSTEN and MOLYBDENUM SHEET

BY MUREX LIMITED

MUREX LIMITED *(Powder Metallurgy Division)*
RAINHAM · ESSEX · *Telephone: Rainham, Essex* 3322
Telex 28632. *Telegrams: Murex, Rainham—Dagenham Telex*
London Sales Office: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1. *Telephone: EUSton* 8265

Courtburn Variable Speed Positioners for circumferential welds being constructed in our Bedford works

WORK HANDLING EQUIPMENT for welding

OPERATOR'S PLATFORMS
CYLINDER ROTATORS
POWERED POSITIONERS
CLAMPING MACHINES
WELDING PLATENS

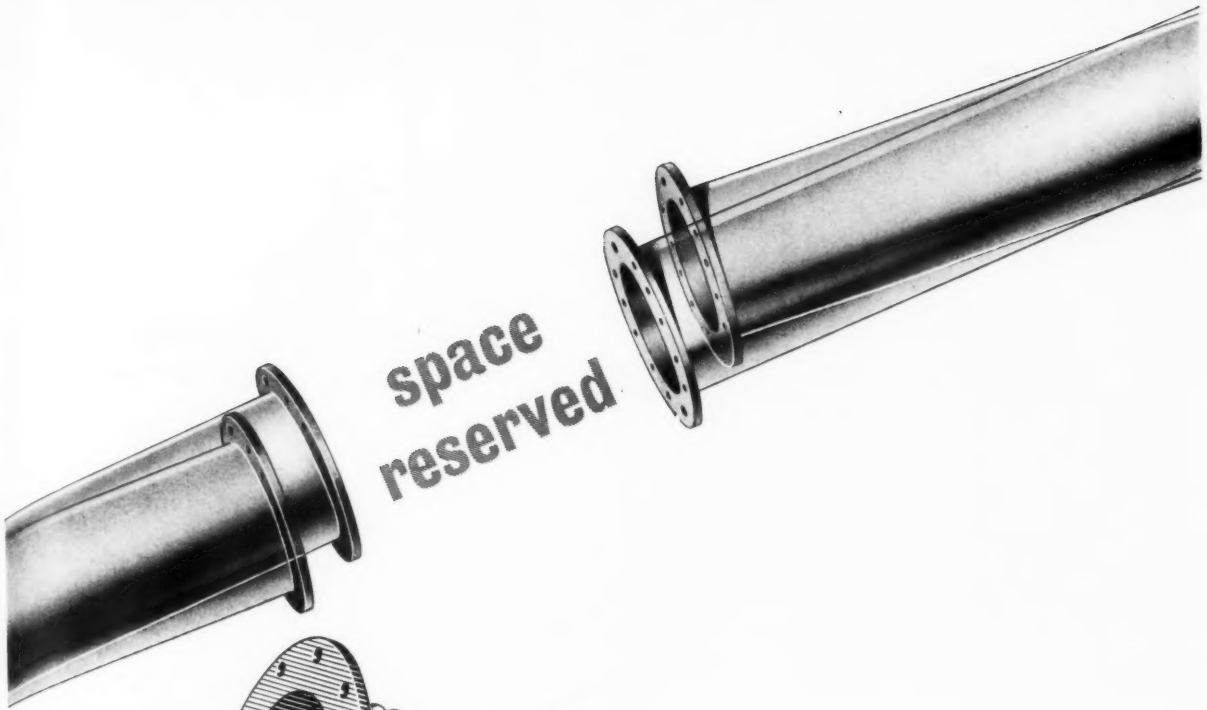
COMPLETE AUTOMATIC WELDING SCHEMES DESIGNED AND SUPPLIED

Follow the example of dozens of the leading engineering firms—choose Courtburn equipment

Catalogue gladly sent on request

COURTBURN
POSITIONERS LIMITED

SALES DIVISION, GOLDINGTON BURY, BEDFORD
Telephone: 4587-8-9



space reserved

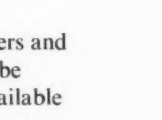
for a

teddington bellows

Movement of pipe work under modern high-pressure and high-temperature conditions is absorbed efficiently by TEDDINGTON BELLOWS EXPANSION JOINTS. Teddington Bellows are of highest quality stainless steel, flawlessly butt-welded to ensure perfect uniformity of wall for maximum durability. Normal production ranges from 1 inch to 7 feet diameters and larger sizes can be made. Your expansion problem can be solved by our experienced engineers who are always available for consultation and recommendation.

Send for our descriptive brochure No. R72

PIPES ON THE MOVE PREFER



TEDDINGTON BELLOWS

TEDDINGTON AIRCRAFT CONTROLS LTD., INDUSTRIAL BELLOWS DIVISION
AMMANFORD, CARMARTHENSHIRE. *Telephone Ammanford 455*

SINGLE PHASE AND POLYPHASE
WATTHOUR METERS
SYNCHRONOUS TIME SWITCHES
SYNCHRONOUS MOTORS
AND MOTOR UNITS

SANGAMO WESTON

PANEL & SWITCHBOARD
INSTRUMENTS
D.C. Moving Coil, A.C. Rectifier, H.F. Thermocouple
A.C./D.C. Moving Iron

PORTABLE INSTRUMENTS
D.C. Moving Coil, A.C. Rectifier, H.F. Thermocouple
A.C./D.C. Moving Iron, A.C./D.C. Dynamometer

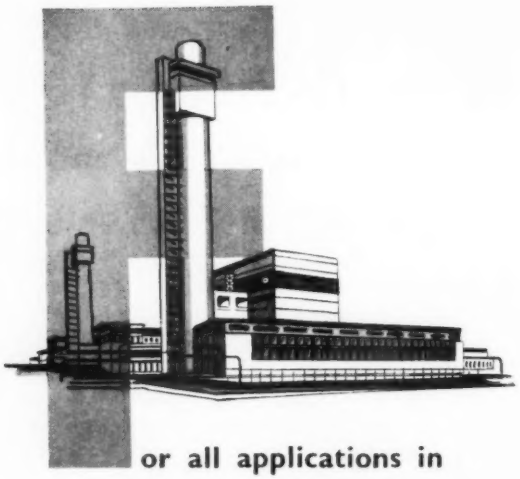
LABORATORY STANDARD
INSTRUMENTS
D.C. Moving Coil, A.C./D.C. Dynamometer

CURRENT TRANSFORMERS
FREQUENCY METERS
ALL-PURPOSE TEST SETS
AIRCRAFT INSTRUMENTS
RATIOMETERS . TACHOMETERS
ELECTRICAL THERMOMETERS
WESTON STANDARD CELLS
"PHOTRONIC"
PHOTO ELECTRIC CELLS
PHOTOMETERS

SANGAMO WESTON LTD.
ENFIELD, MIDDLESEX
Telephone: ENField 3434 (6 lines) and 1242(6 lines)
Grams: Sanwest, Enfield
Scottish Factory: Port Glasgow, Renfrewshire
Port Glasgow 41151

Branches: London, CHAncery 4971 . Glasgow, Central 6208
Manchester, Central 7904 . Newcastle-on-Tyne, Newcastle 26867
Leeds, Leeds 30867 . Liverpool, Central 0230 . Wolverhampton,
Wolverhampton 21912 . Nottingham, Nottingham 42103
Bristol 21781 . Southampton, Soton 23328 . Brighton, Brighton 28497

SW/15



or all applications in
Nuclear Power plants . . .
. . . continue to fit

FREMO STAINLESS STEEL

bolts, nuts, screws
and other fasteners
with corrosion,
contamination and
heat resistant
properties.

FREMO
TRADE MARK

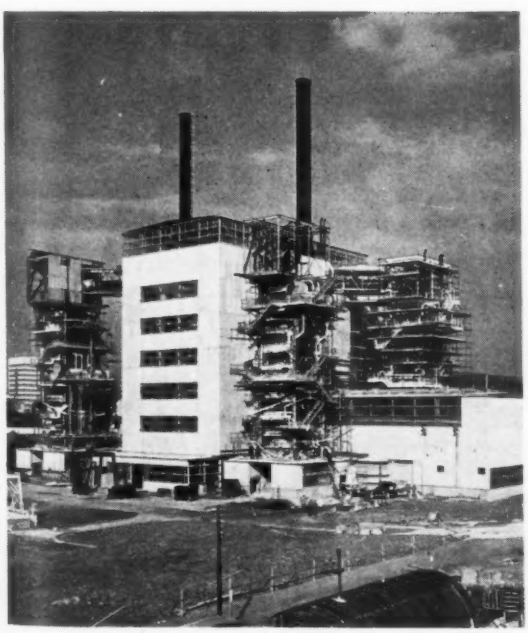
FREDERICK MOUNTFORD
(BIRMINGHAM) **LIMITED**

Fremo Works, Moseley St., Birmingham, 5
Tel. MIDland 7984 PBX
Grams 'FREMO' Birmingham

Photograph reproduced by courtesy of the United Kingdom Atomic Energy Authority.

HILLS (WEST BROMWICH) LIMITED

at Britain's Atomic Plants



We are proud to have been associated with the United Kingdom Atomic Energy Authority in the construction of so many of its projects. We have been privileged to supply our products for use in the construction of Calder Hall and other Atomic Plants throughout the country. Architects and Contractors are invited to contact our nearest branch office for further details.

Products supplied for Britain's Atomic Plants include :

- 'PRESSWELD' FRAMEWORK
- VERTICAL PATENT GLAZING OPENING LIGHTS and FLASHINGS, etc.
- LANTERN LIGHTS and DECKLIGHTS
- STACK VENTILATORS
- PURPOSE-MADE STEEL WINDOWS, DOORS, SCREENS and PRESSED STEEL COMPONENTS
- LOUVRED WALL VENTILATORS
- PRE-CAST CONCRETE UNITS

HILLS (WEST BROMWICH) LIMITED, ALBION ROAD, WEST BROMWICH, STAFFS. *Tel.:* WESt Bromwich 1811 (15 lines)
LONDON : CHAPONE PLACE, DEAN STREET, W.1. *Telephone:* GERrard 0526/9
Branches at Birmingham (Midland 5175), *Manchester (Blackfriars* 3382/3), *Bristol* (24765), *Newcastle-on-Tyne* (25060), *Glasgow (City* 5564) *and Belfast (Dundonald* 3526)

WINDOW TANKS
FOR
DOUNREAY
MANUFACTURED AND SUPPLIED BY

EVANS

of PORTSMOUTH

Zinc bromide viewing tanks will be a prominent feature in the irradiated fuel element laboratory at Dounreay. These vital units represent our contribution towards the building of this new reactor.

We are ideally equipped to assist in this new field of development, particularly in the manufacture of remote control equipment and special purpose machinery.

Your enquiries will receive our prompt attention and fullest co-operation.

A.I.D. and
A.R.B. Approved

Tel.:
Portsmouth
32233

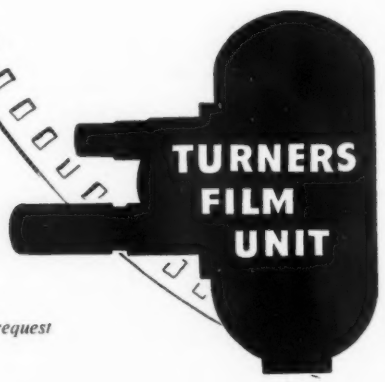
J. EVANS & SON (Portsmouth) Ltd
Marcyn Works, Goldsmith Avenue
PORTSMOUTH

Complete Film Records for Industry

by TURNERS of NEWCASTLE

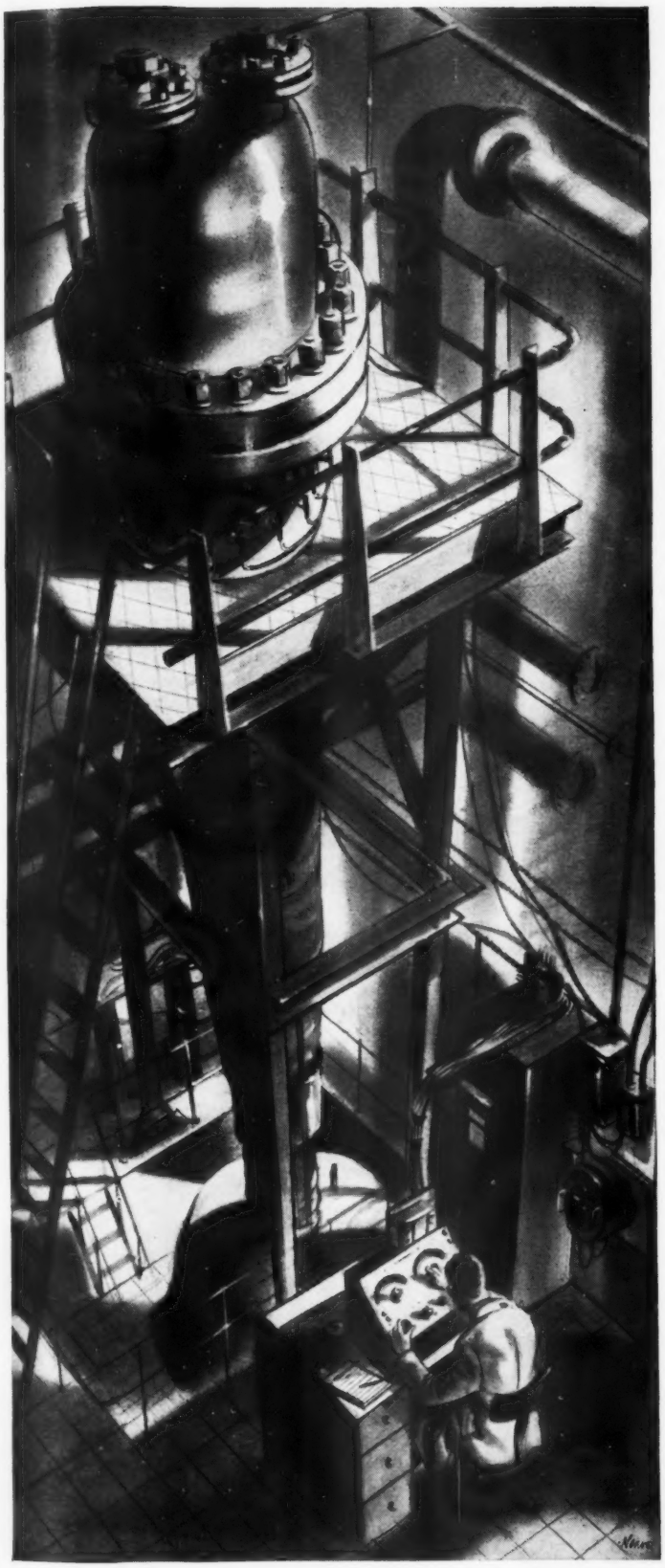
Turners have already produced Public Relations and Prestige Films, Staff Recruitment Films, Scientific Record Films, Industrial Films, Advertising Films and Documentary Films for such firms as:

Bartram & Sons Ltd.
Churchill Gear Machines Ltd.
Cleveland Bridge & Engineering Co. Ltd.
William Doxford & Sons Ltd.
Furness Shipbuilding Co. Ltd.
Pilkington Bros. Ltd.
Reyrolle & Co. Ltd.
Smiths Dock Co. Ltd.
South Durham Steel & Iron Co. Ltd.
Vickers-Armstrong (Shipbuilders) Ltd.



We will gladly supply further information on request

Camera House, Pink Lane, Newcastle upon Tyne. Tel: 2-5391.



G.E.C. Nuclear Research and Development—No. 1

The Hot Box

Complete reliability in operation is perhaps the most vital requirement in the design of equipment installed in a nuclear reactor. Much of the research undertaken by the G.E.C. in the laboratories of its Atomic Energy Division has been towards this end. Just one of the many research tools used in this work is popularly known as the "hot box".

The "hot box" is constructed much in the form of a reactor standpipe and is designed to house all the components which will operate in a reactor standpipe.

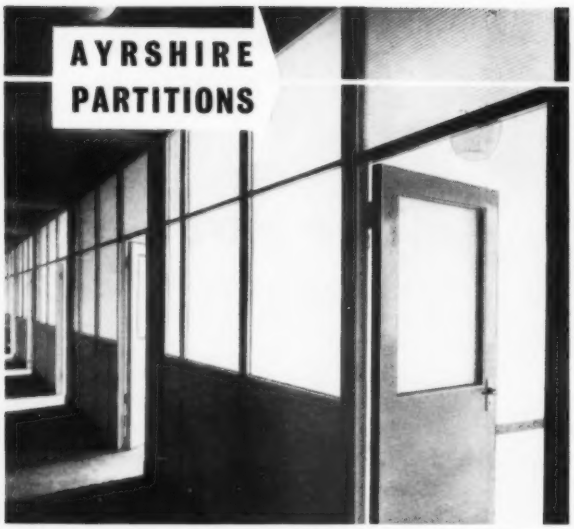
At its lower end, beneath the laboratory floor, it is connected to an electrically heated vessel filled with the coolant gas and, by this means, conditions of temperature, pressure and atmosphere similar to those experienced in reactor operation, can be reproduced inside the "hot box". It is therefore possible to investigate the heat distribution likely to be found in the reactor standpipes, to carry out life-tests on the control-rod driving mechanism, and to check the operation of the burst-slug detection equipment and of numerous other smaller items.

This is just one of the ways in which the G.E.C. is ensuring the safe, reliable and economical harnessing of nuclear energy.

G.E.C.

Atomic Energy Division

THE GENERAL ELECTRIC COMPANY LTD. MAGNET HOUSE, KINGSWAY, LONDON, W.C.2.
A218

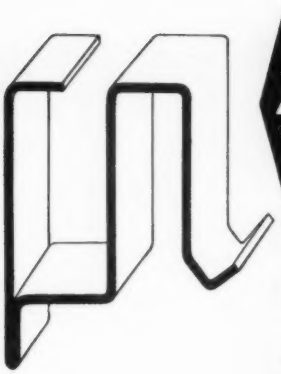


Functional in design: flexible in use. You can quickly divide floor space any way you want. Installation is fast, clean, simple, completely permanent in appearance, yet easily movable. Available in a wide range of smart and distinctive colours.

The stoved enamel finishes are applied at the factory. You should have the Ayrshire Partitions Catalogue by you. The Ayrshire complete Partition Service does the whole job from planning to glazing.

AYRSHIRE

THE AYRSHIRE DOCKYARD COMPANY LIMITED
IRVINE Phone : Irvine 2271/3
Also at: Pocketnook Street, St. Helens, Lancs
London office: 47 Victoria Street, London, S.W.1. Phone: ABBey 5521



AYRSHIRE

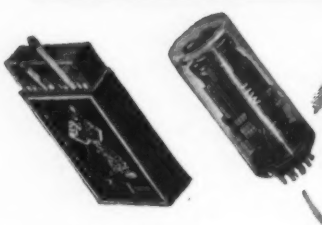
Cold formed SECTIONS

Within the limits of 4 in. depth and 18 in. developed width, we can roll sections to almost any shape, at a minimum tool cost. For standard angles, channels and lipped channels there is no extra cost at all. Thickness from 26 gauge to 3/16 in.; any transportable length; mild steel, alloy steel, aluminium—almost any metal. Accuracy guaranteed. Can we quote or advise you?

AYRSHIRE

THE AYRSHIRE DOCKYARD COMPANY LIMITED
IRVINE Phone : Irvine 2271/3
Also at: Pocketnook Street, St. Helens, Lancs
London office: 47 Victoria Street, London, S.W.1. Phone: ABBey 5521

ELECTRO-MAGNETIC RELAYS?..



Send to Simmonds!
who have a range of
1000 NEW TYPES
by MTI (Matériel Technique Industriel)

Delivery 14 - 21 days for most types

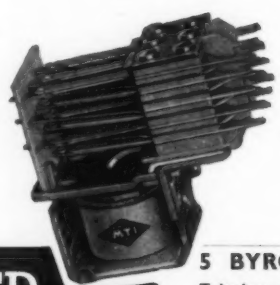
★ Most models can be fitted with dust covers or hermetically sealed.

★ Range includes certain models hermetically sealed, all metal gas filled with glass base, and built in adjustable thermal delay.

★ **Post Office types 3000 and 600 relays of our own manufacture to specification. Guaranteed to full A.I.D. and I.E.M.E. standards.**

Sole concessionaires for U.K. and Dominions on behalf of M.T.I.

Operating from **1 Milliwatt** to **1 Kilowatt** with up to **96 changeovers** at **10 amps. per contact.**



L. E. SIMMONDS LTD.

5 BYRON ROAD, HARROW, MIDDX.
Telephone: HARrow 7797/9 Telegrams: SIMRELAY HARROW
(Manufacturers and Trade enquiries only)

OPERATION CLEANLINESS

In nucleonic projects, as in surgery, clean air is vital; and it is our job to supply clean air to the most stringent requirements.

In conjunction with our associates, American Air Filter Co. Inc., we can offer the most comprehensive range of air cleaning equipment: inlet filters, gas filters, discharge filters, and complete air conditioning plant. In addition, we make the widest range of high-efficiency circulating fans and dust control equipment.

The following are particularly suitable for nucleonic projects. Further information of these—and our other products—will gladly be supplied on request:

MULTI-DUTY:	*A positive self-cleaning viscous impingement filter with very high efficiency.*
ROLL-O-MATIC:	*A self-maintaining filter which needs attention only at long intervals.*
PL-24:	*A dry filter employing an inexpensive replacement medium. Compact; easy to maintain.*
ELECTRO-PL:	*A dry type electronic precipitator of similar constructional design to the PL-24.*
AMER-GLAS:	*A plastic bonded glass filament throw-away filter.*
ROTO-CLONE:	*A wet dynamic precipitator for heavy dust loads.*

AIR CONTROL
INSTALLATIONS LIMITED

RUISLIP · MIDDLESEX · RUISLIP 4066

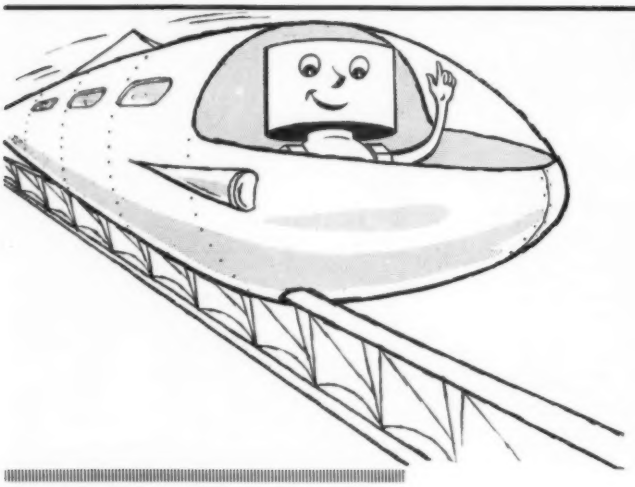
LONDON · BIRMINGHAM · MANCHESTER · NEWCASTLE · GLASGOW

Air Control are the sole manufacturing licensees in Great Britain for products of the American Air Filter Co., Inc.

1936 1957

WS 1234

FILTERS · DUST COLLECTORS · AIR CONDITIONERS · FANS · FILTERS · DUST COLLECTORS · AIR CONDITIONERS · FANS · FILTERS · DUS



It can't be done without CONTROL

We don't know whether it's the railway's idea of economy to make one track do the work of two, but the fad for monorails seems to be spreading all over the place. They tell us they go faster, smoother, safer, quieter—but we two-footed ancients have an ingrained distrust of anything lacking inherent equilibrium. Of course, it's all a matter of reliable controls—our slide-rule wallahs tell us they are foolproof and safe.

We ought to be able to understand this, for we make much the same claims for Magnetic Valves. Twenty-five years of skill and experience in the business have been used to make Magnetic Valves exercise unfailing automatic or remote control over industrial gases and liquids like air, steam, oil and coal gas. No help is enlisted from glands, driving shafts or stuffing boxes. If you ask us for more details, we will send you illustrated literature showing the standard range. Special valves up to 12 in. orifice can be supplied.

THE MAGNETIC SAFETY CUT-OUT VALVE

is of the semi-automatic hand opening electrically maintained pattern ensuring instantaneous and complete closure in the event of "packless" construction, and can be supplied in sizes ranging from 1" up to and including 12"

Alternative types of hand operating gear are available including hand lever and push-up spring return patterns.

The installation of this valve is an essential precaution with all types of gas and oil fired equipment, and ensures complete isolation of the fuel in the event of an interruption of the electrical supply WITHOUT automatic opening when such electrical supply is restored.

MANY VALVES AVAILABLE ex. stock. *VALVES DESIGNED for special conditions*

the Magnetic Valve Company LIMITED

28 ST. JAMES'S PLACE, LONDON, S.W.1 Telephone: HYDe Park 7588

NON FERROUS METALS

For the most comprehensive stock available

BRASS, COPPER, PHOSPHOR BRONZE, GUN METAL, NICKEL SILVER
ALUMINIUM, DURALUMIN, TIN PLATES, ZINC SHEETS
TEE RODS, TUBES, STRIPS, SHEETS, BLANKS, ANGLES, CHANNELS
RIVETS, SCREWS, NUTS, WASHERS, GAUZE, SOLDER
PERFORATED SHEETS, STUDDING

J. SMITH & SONS (CLERKENWELL) LTD.
42/54, ST. JOHN'S SQUARE, CLERKENWELL, LONDON, E.C.1

phone: CLE 1277 (14 lines)
Screw Dept: CLE 0925

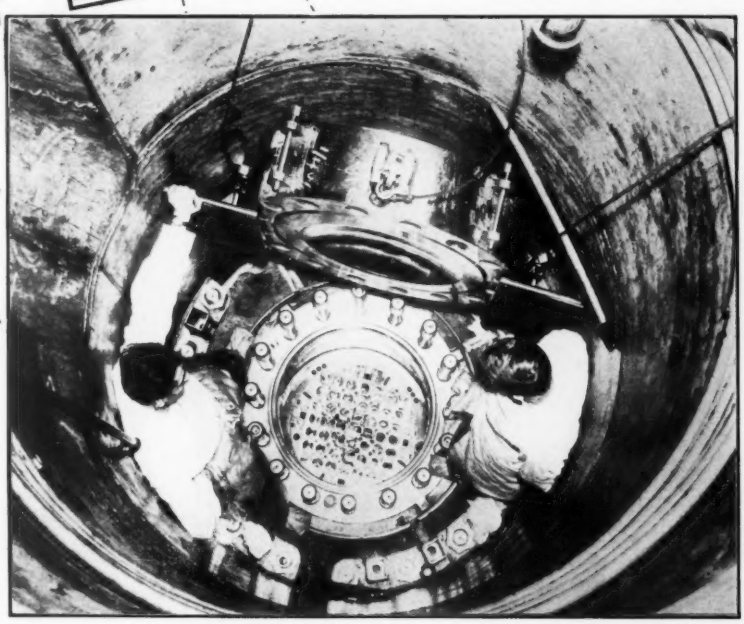
competitive power FROM THE atom

APPR-1

The Appr-1 has just completed its 700 hours acceptance test with outstanding success.

This is a prototype of the ALCO pressurized water reactor for which Humphreys & Glasgow hold world marketing rights outside North America. Most of the Nuclear Plant is being manufactured by Daniel Adamson & Co., Ltd., of Dukinfield.

Oil and coal prices are rising steadily whereas the cost of nuclear power is falling and is already competitive in most places. Humphreys & Glasgow would welcome enquiries for either immediate installation or long range planning.



Overhead view of core structure in APPR-1 Reactor as technicians make final installation. Note 7 x 7 grid, with corners missing, that provides space for fuel elements and control rods.

HUMPHREYS & GLASGOW LTD *TELEPHONE : VICTORIA 8454*

HUMGLAS HOUSE · CARLISLE PLACE · LONDON S.W.1 **ALSO IN FRANCE · GERMANY · CANADA · AUSTRALIA · SOUTH AFRICA · JAPAN**

AUSTRALIA AUSTRIA BELGIUM BRAZIL CANADA

THE WORLD

CHILE DENMARK ECUADOR FRANCE GERMANY

IS WATCHING

INDIA ITALY JAPAN NETHERLANDS NORWAY

BRITISH

PAKISTAN PANAMA PERU PORTUGAL SPAIN

ATOMIC NEWS

SWEDEN SWITZERLAND URUGUAY

Potential buyers in these and other markets are now seeing "British Atomic News—No. 1."

You can participate in this new, vital sales promotional scheme. Six new productions are being planned now.

If your business concerns atomics, electronics, automation, instrumentation or other fields, show and tell the world in full colour and sound.

Reasonable cost— no "extras".

If you have not seen "British Atomic News—No. 1" we will be glad to screen it for you.

Full details of the complete B.A.N. scheme will be sent on request.

BRITISH ATOMIC NEWS LIMITED 3 Albemarle Street, London, W.1.
Telephone: MAYfair 9361
Cables: Atomnews, London

In association with Hartley-Ward Films Ltd.

COLLOIDAL GRAPHITE
...in electronic and allied fields

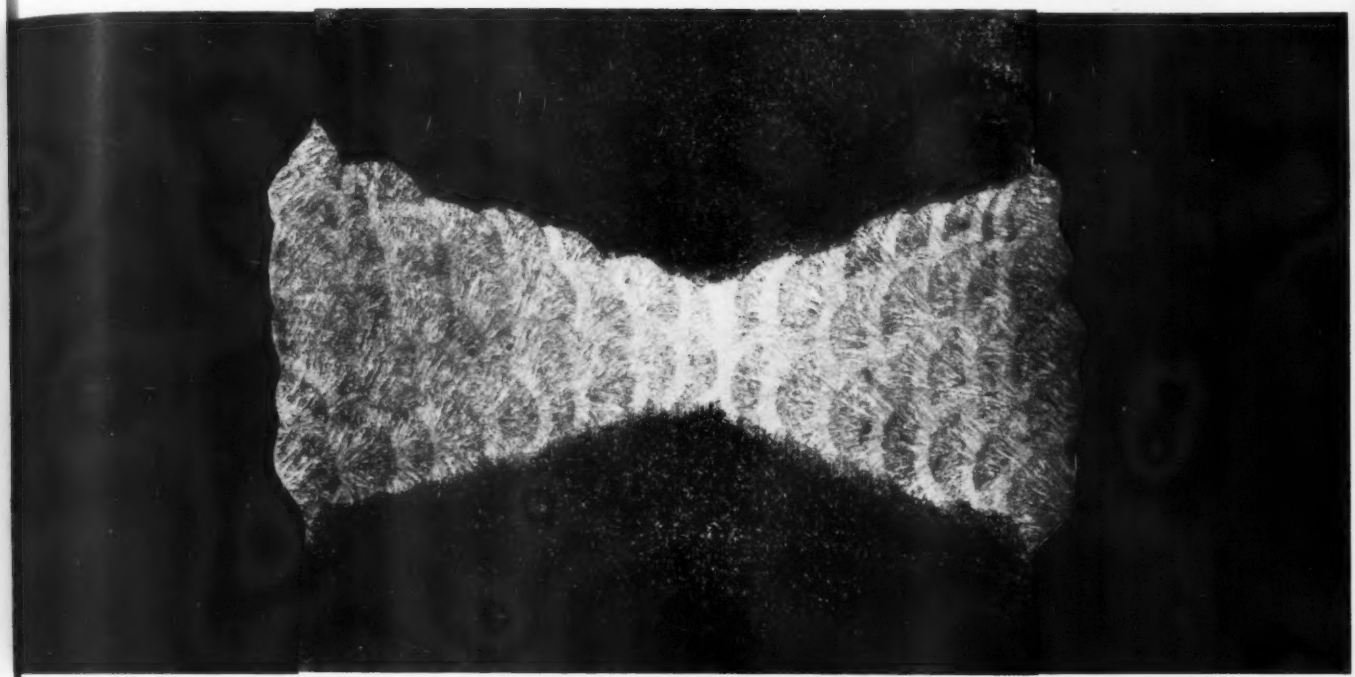
Coatings or films formed with this versatile product are, for practical purposes, chemically and physically inert; they can be used in close proximity to radio-active material and are transparent to radio-active emanations. The many applications for 'dag' colloidal graphite include the lubrication of reactor control mechanisms, louvres and sliding surfaces; the treatment of screw threads to prevent seizure, dry film and high temperature lubrication for I/c engines, air compressors, pumps, reduction gears, and for ball, roller or plain bearings under conditions of high load, stress or speed.

An Acheson service engineer will be pleased to call on you, or technical leaflets will be sent on request.

dag
REGD TRADE MARK
DISPERSIONS

ACHESON COLLOIDS LTD., *18, PALL MALL, LONDON, S.W.1*
Telephone: Whi 2034-9 *Telegrams: Oildag-Piccy-London*

THICK PLATE WELDING NEEDS MUREX "FORTREX 35A" ELECTRODES

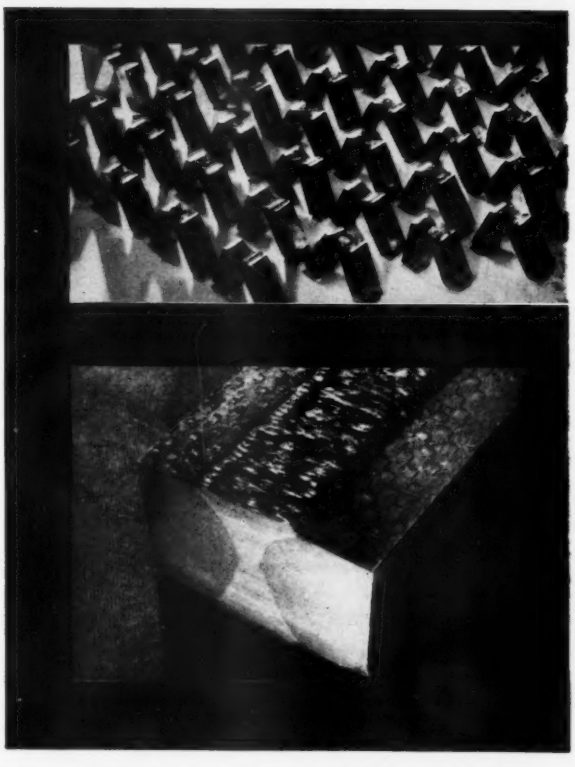


The problem of welding large vessels with walls of extra thick plate (e.g. 3-4 inches thick and over) and obtaining good and uniform physical properties throughout the whole section of the welded joint is of great importance in nuclear energy and other industrial applications.

This welding problem presents unusual difficulties and it has recently been solved after long and intensive research work in the Murex Research Laboratories by the development of a special new electrode known as the Murex "Fortrex 35A" electrode.

The "Fortrex 35A" electrode gives all the required properties in the welded joint in extra thick plates and the weld metal has particularly good impact properties — far above minimum requirements — at sub-zero temperatures. The electrode also has all the advantages of the standard "Fortrex 35" type. It is an all position electrode; it is simple to use, slag removal is easy and the radiographic quality of the weld metal is sound.

"Fortrex 35A" electrodes and the technical facilities of the Murex Organisation are at your service for the welding of extra thick plate.



MUREX ELECTRIC ARC WELDING EQUIPMENT & ELECTRODES

E.27

MUREX WELDING PROCESSES LTD., Waltham Cross, Herts. Tel : Waltham Cross 3636

LABGEAR

PYE

Labgear in association with Pye...

We invite you...

to make full
and free use,
without any
obligation
of
Our Consultant
Applications
Engineering Department.

Isotope techniques
are helping almost
every branch of
industry, medicine,
agriculture and
research.

Our consultants
will be glad to
help you.

PRINTING COUNTER TYPE D4123

it counts AND it prints

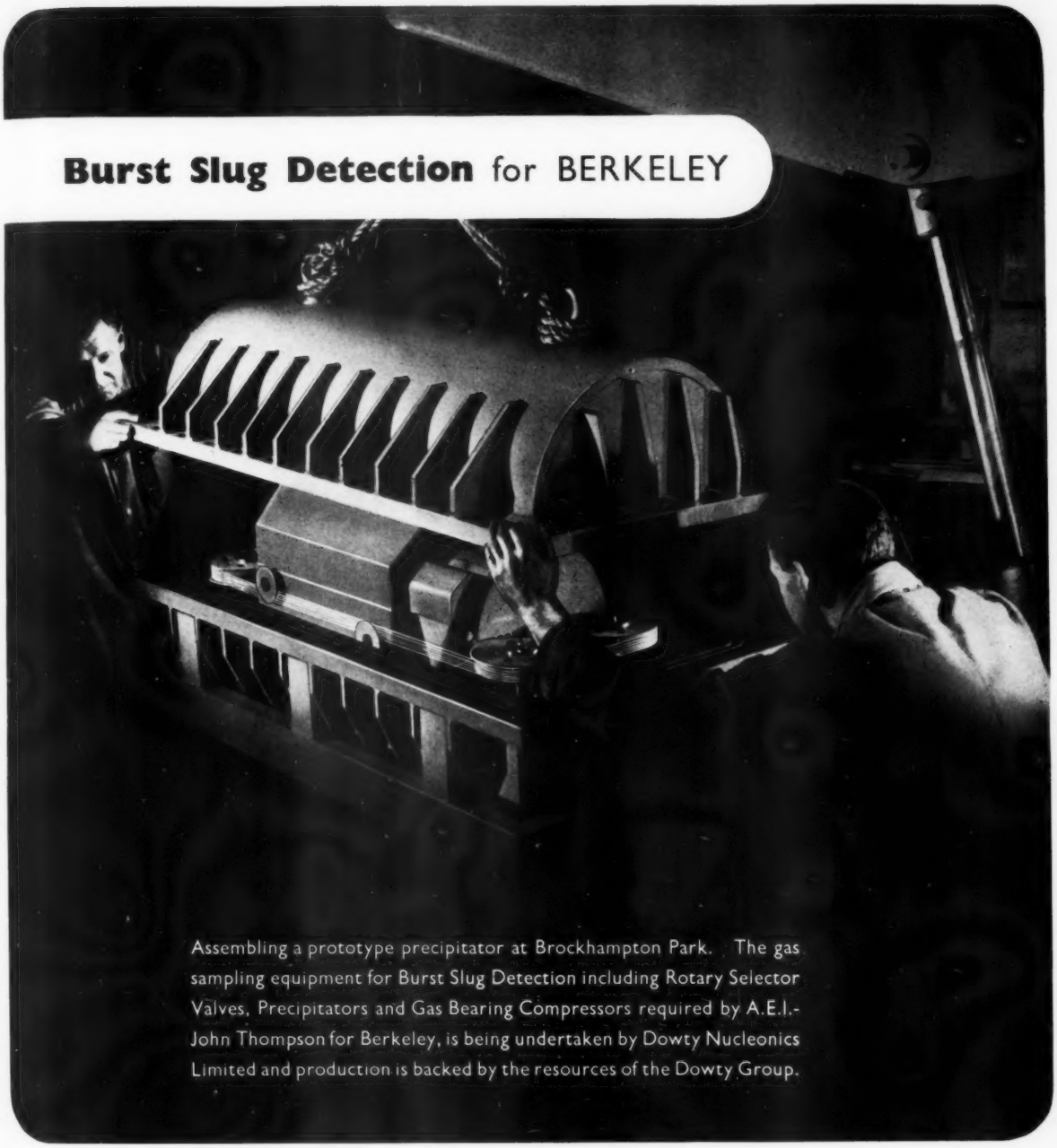
and relieves valuable technical personnel of a host of tedious operations normally necessary during repetitive counting.
Typical applications include :–
Automatic digital nuclear applications.
Industrial control systems.
Digital repetitive recording of r.p.m., time, pulses, etc.

Full details and specifications of our full range of instrumentation from :—

Labgear Ltd

WILLOW PLACE, CAMBRIDGE, ENGLAND.
Tel: Cambridge 2494.

Burst Slug Detection for BERKELEY



Assembling a prototype precipitator at Brockhampton Park. The gas sampling equipment for Burst Slug Detection including Rotary Selector Valves, Precipitators and Gas Bearing Compressors required by A.E.I.-John Thompson for Berkeley, is being undertaken by Dowty Nucleonics Limited and production is backed by the resources of the Dowty Group.

DOWTY *Nucleonics* LTD.

MEMBER OF THE DOWTY GROUP

BROCKHAMPTON PARK
ANDOVERSFORD · GLOS
Telephone
ANDOVERSFORD 391/2/3
Telegrams
"INVENTION," Cheltenham

of the Atom

To nuclear power generation Simon-Carves bring immense experience of major plant construction and civil engineering for the fuel, electricity and heavy chemical industries, including the building of orthodox steam power stations for more than thirty years.

In the building of nuclear power stations Simon-Carves assume responsibility for all civil engineering and reinforced concrete design and construction, including nuclear reactor structures and biological shielding, and for complete heat-exchange steam-generating plant and water treatment systems.

Simon-Carves are conducting continuous research, both in their own laboratories at Cheadle Heath and jointly with The General Electric Company at Erith, on the improvement of steam conditions resulting from improved reactor outputs, on the use of pre-stressed concrete in reactor structures and elsewhere, and on the safe disposal of radio-active waste.

This work is playing an important part in the development of future advanced designs and in the reduction of cost per kilowatt.

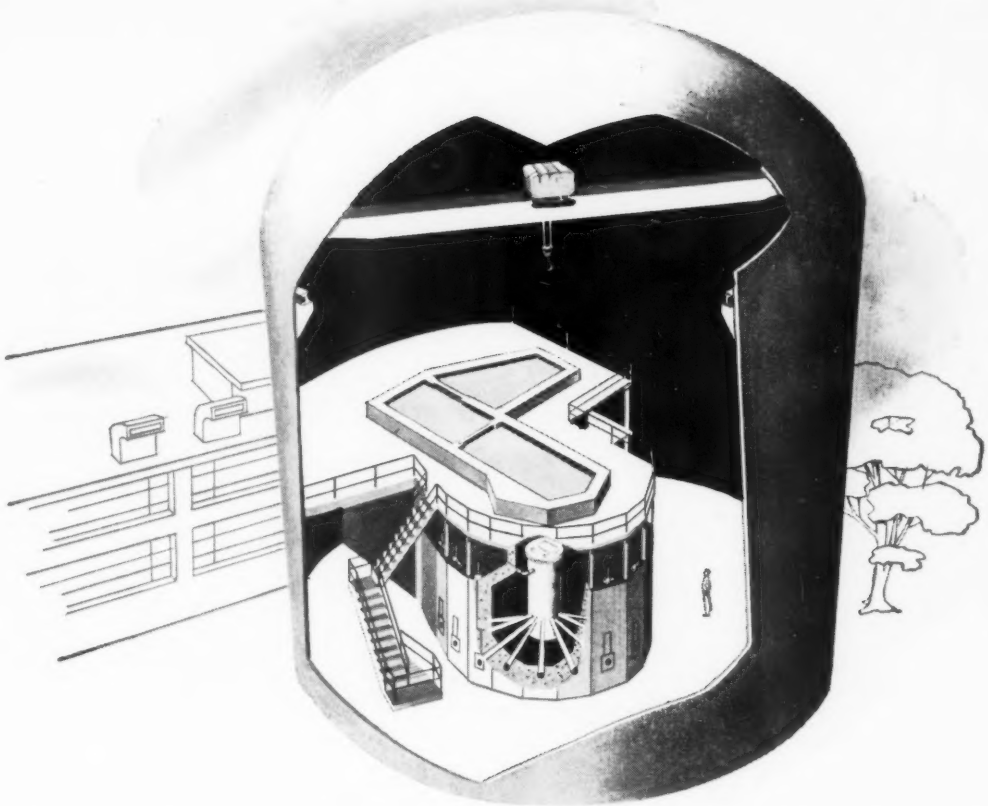
Simon-Carves Ltd

SIMON ENGINEERING GROUP

NUCLEAR POWER DIVISION / Cheadle Heath, Stockport

IN ASSOCIATION WITH THE GENERAL ELECTRIC CO. LTD
THE MOTHERWELL BRIDGE & ENGINEERING CO. LTD · JOHN MOWLEM & CO. LTD

SC177(A)/PS



REACTOR CENTRUM NEDERLAND

acf supplies 20,000 kw light water reactor

Now being designed and fabricated by acf Industries, Incorporated, the 20,000 kw light water reactor facility for the Reactor Centrum Nederland will be used for a broad range of research and development programs in nuclear science and technology.

Experimental facilities include 12 ports, four rabbits and one irradiation facility adjacent to the core region. Average thermal flux in the core will be 1.38×10^{14} n/cm²/second. Reflector elements are beryllium, designed to be interchangeable with fuel elements.

Nuclear Products-Erco Division is staffed and equipped to design and build complete reactor facilities for power, research, materials testing, and other purposes. We cordially invite inquiries relating to design and manufacture of reactors, components, and associated equipment.

acf REACTORS
currently under design and construction

1,000-5,000 kw heavy water research reactor for the Massachusetts Institute of Technology.

5,000 kw heavy water research reactor for the Italian National Committee on Nuclear Research.

20,000 kw light water materials testing and research reactor for Reactor Centrum Nederland.

30,000 kw light water materials testing and research reactor for Aktiebolaget Atomenergi of Sweden.

10,000 kw light water materials testing reactor for the Nuclear Engineering Test Facility, Wright-Patterson Air Force Base, Ohio.

A preliminary design of a 10,000-20,000 kw light water materials testing reactor for the Case Institute of Technology.

acf **nuclear products-erco**

Division of acf Industries Incorporated, 508 Kennedy Street, N.W., Washington, D.C.

I.C.I.

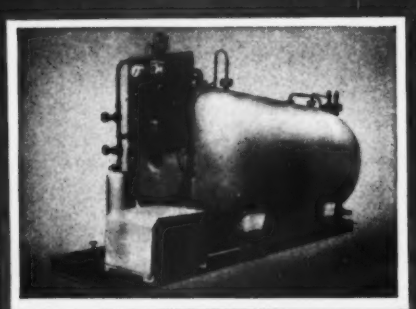
Liquid Carbon Dioxide in Bulk

Express delivery to Atomic Reactors

I.C.I.'s express delivery service of pure liquid carbon dioxide in bulk assures ample supplies to the atomic reactors at Calder Hall. The exacting requirements of the U.K. Atomic Energy Authority are fully met, and deliveries by I.C.I.'s powerful, specially constructed road-tankers ensure that vital work is never delayed.

I.C.I. supplies storage tanks of five-ton capacity *complete and ready for use*, and advice is offered in the design of special-purpose tanks of greater capacity.

A full technical service is available on the installation of storage tanks, and on all other aspects of the handling and distribution of carbon dioxide.



Without effort and without loss, pure I.C.I. carbon dioxide is always on tap, where and when it is wanted.

Full information on request

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

CO_2

A COMPLETE PRECISION AND PROTOTYPE NUCLEAR ENGINEERING SERVICE

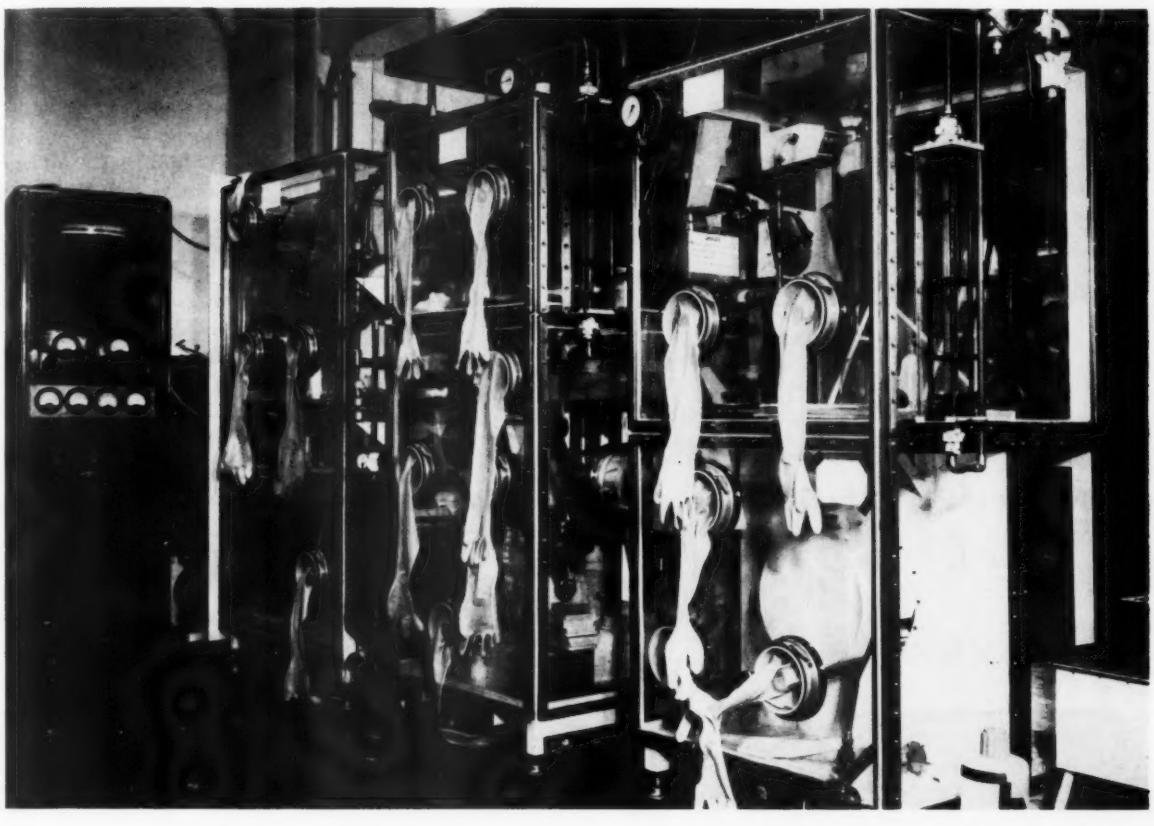
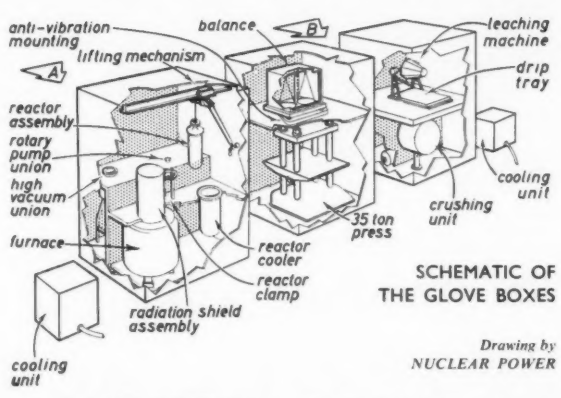


Photo by courtesy of A.E.R.E

A SUITE OF GLOVE BOXES FOR EXPERIMENTAL PRODUCTION OF U-233 METAL



SCHEMATIC OF THE GLOVE BOXES

Drawing by NUCLEAR POWER

- Consulting engineers
- Designers and manufacturers of nuclear and specific prototype equipment
- Remote manipulation equipment
- Vacuum casting equipment
- High vacuum equipment
- Electronic engineers
- Radio frequency engineers
- Low temperature refrigeration
- Installation contractors

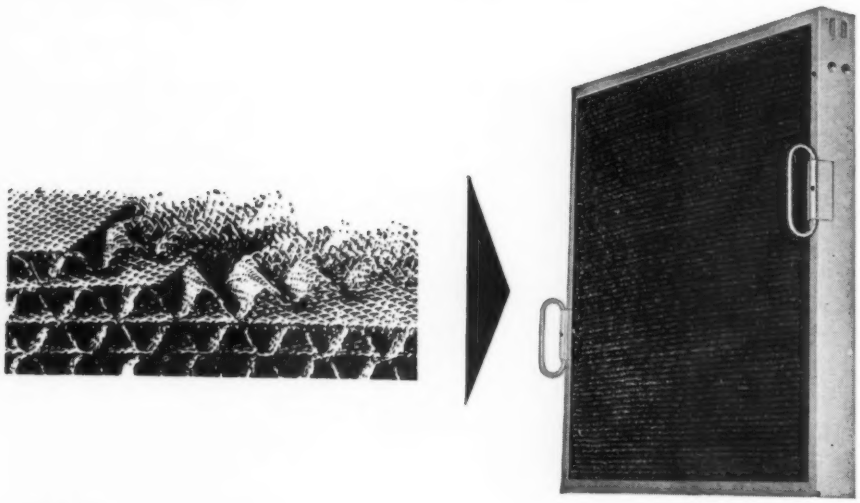
WESTERN DETAIL MANUFACTURERS LTD.

WESTERN WORKS, STAPLE HILL, BRISTOL

Tel: 65-5097 and 65-2825

Cables and Telegrams: Aries, Bristol, England

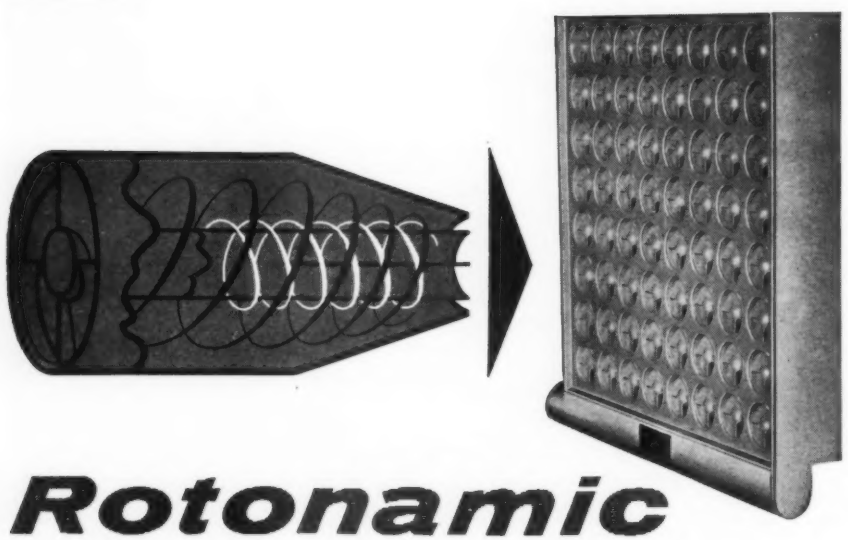
Far-Air air filter



Maximum efficiency and minimum pressure loss are important characteristics of the FAR-AIR filter. Easily accessible and washable elements are used. Their design is such that **one cubic foot of screening material can trap up to 25 lb. of solid matter without loss of efficiency !**

INTERMIT LTD. has set up a nation-wide filter cleansing service to provide low-cost maintenance. An automatic 3-stage washer of FAR-AIR design is available for large installations, where the cost of a special machine is justified.

2 revolutionary new filtration principles



With extremely high efficiency on particles in the range below 5 microns, the ROTONAMIC multiple-tube cyclonic air cleaner is close to 100% efficient in the removal of larger particles.

There are no moving parts, and the ROTONAMIC therefore needs no maintenance. Solids separated from the air are simply collected from a bin.

Rotonamic

multiple-tube cyclonic air cleaner

FAR-AIR LICENCED MANUFACTURERS FOR EUROPE

INTERMIT LIMITED

BRADFORD STREET · BIRMINGHAM

Phone: Midland 7961

product of **Birfield** **Group** experience and resources

Bailey's and Atomic Energy

1949	WINDSCALE PLUTONIUM PILES
1951	CAPENHURST DIFFUSION FACTORY
1953	CAPENHURST DIFFUSION FACTORY
1953	CALDER 'A' PRELIMINARY WORKS
1954	CALDER 'A' MAIN CONTRACT
1955	CAPENHURST DIFFUSION FACTORY
1956	CALDER 'B' MAIN CONTRACT
1957	BERKELEY A.E.I.-JOHN THOMPSON NUCLEAR ENERGY CO. LTD.

N. G. BAILEY & CO., LTD.

Electrical Engineers

BURLEY VALE WORKS, KIRKSTALL ROAD, LEEDS, 4

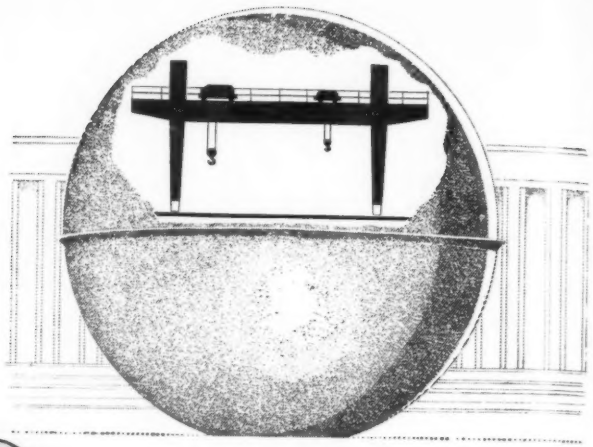
Phone: LEEDS 637854

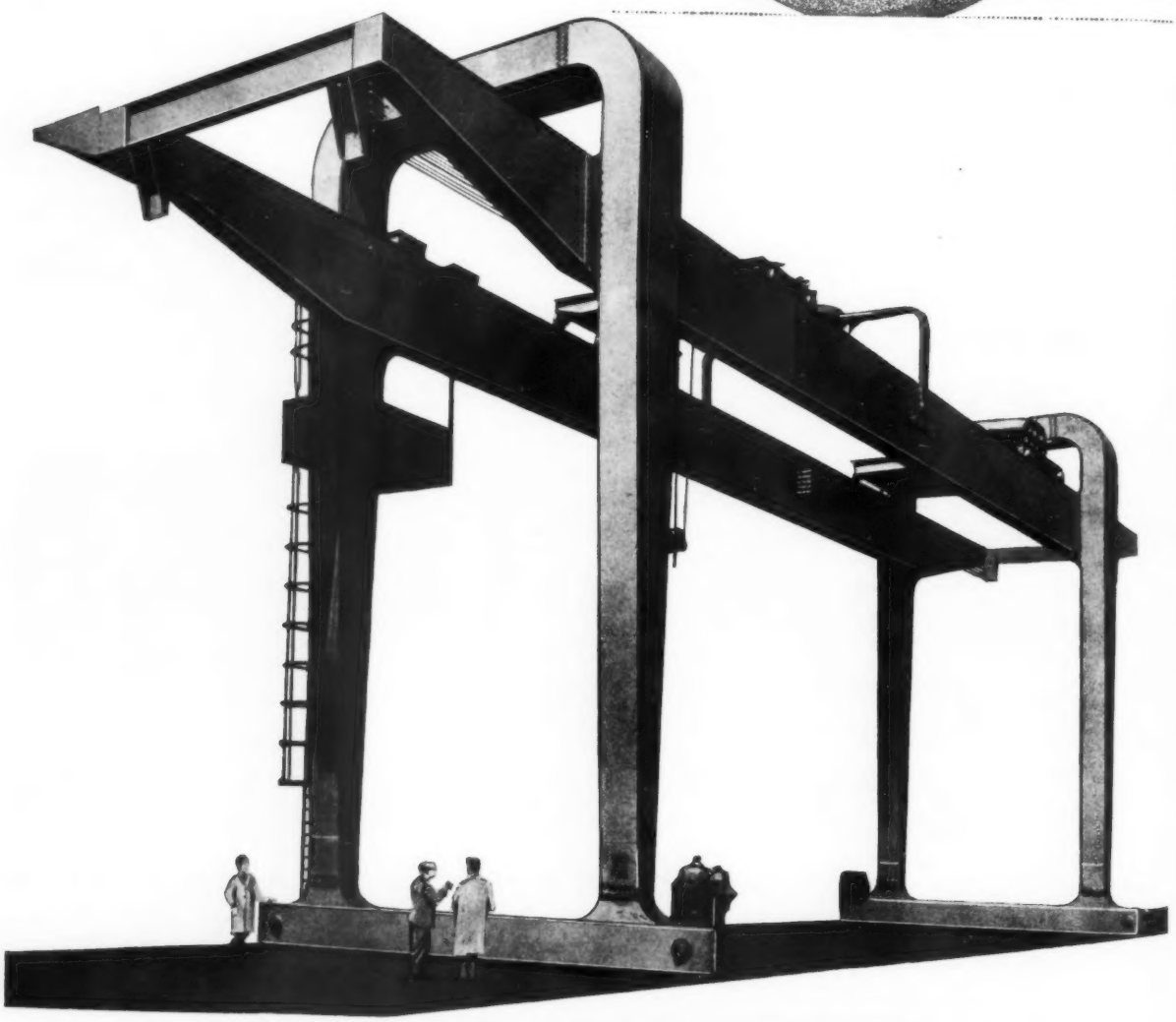
London *Persian Gulf* *Manchester*

for DOUNREAY

This **33 Ton Rotating Gantry Crane** is now installed at the Charge Face in the Reactor Sphere.

It is 115 feet long and 50 feet high. It was delivered precisely on time.





carruthers

J. H. CARRUTHERS & CO. LTD., 27 HAMILTON ST., GLASGOW, S.2. London Office: Abford House, Wilton Rd., Victoria, S.W.1

THE BRADWELL STORY

The design and construction of a Nuclear Power Station makes heavy demands on the skills and resources of British industry.

The following advertisement pages carrying the caption 'THE BRADWELL STORY' comprise the eight member companies of the Nuclear Power Plant Company Ltd and some of the many firms who have been awarded sub-contracts by them.

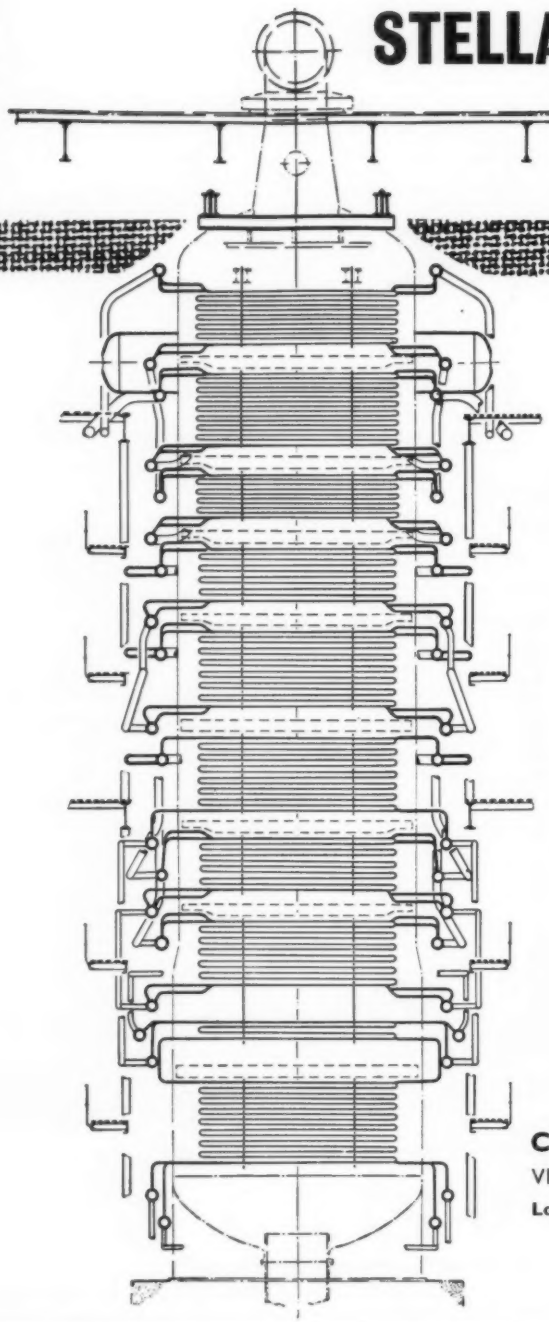
All these firms are participating in the creation of Bradwell-on-Sea Nuclear Power Station, so helping to maintain for Britain world leadership in this new field of nuclear energy.

THESE FIRMS ARE CREATING BRADWELL

BRUNSWICK WHARF,

GOLDINGTON

STELLA NORTH & SOUTH



and now

BRADWELL

for the

CENTRAL ELECTRICITY AUTHORITY.

We are responsible for the
design, manufacture and erection
of the

STEAM RAISING EQUIPMENT

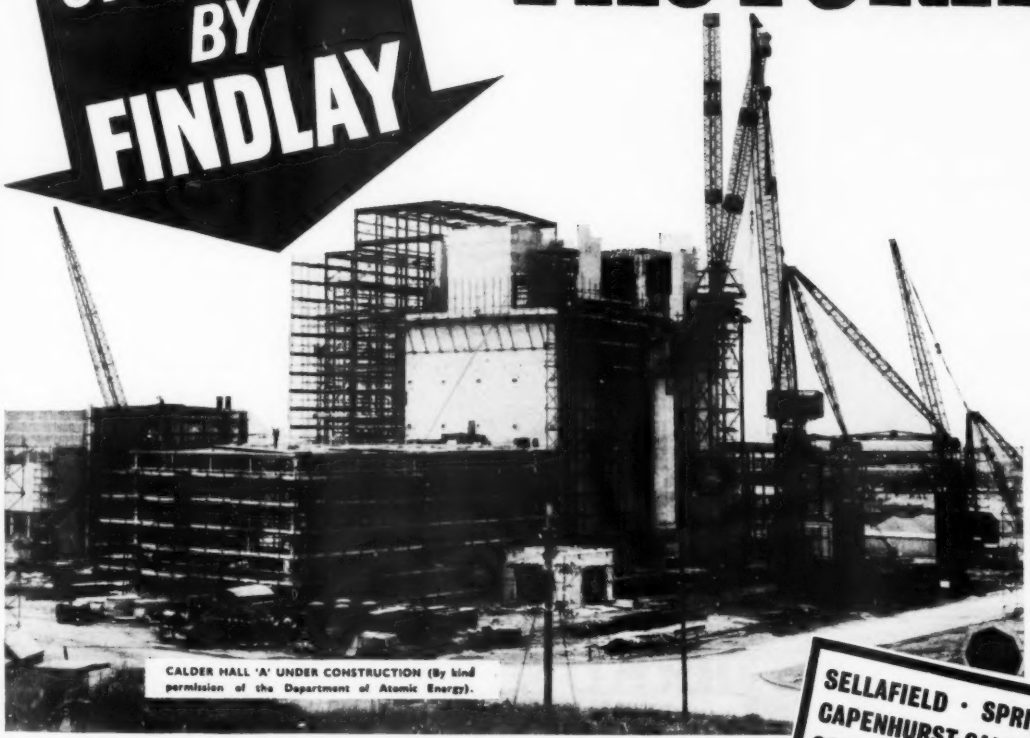
for Bradwell-on-Sea Nuclear Power Station
in collaboration with
Head, Wrightson & Co. Ltd.

Clarke Chapman

CLARKE, CHAPMAN & CO. LTD.
VICTORIA WORKS, GATESHEAD, 8, CO. DURHAM
London Office: DUNSTER HOUSE, MARK LANE, E.C.3.

BRITAIN'S ATOMIC FACTORIES

STRUCTURAL STEELWORK BY FINDLAY



CALDER HALL 'A' UNDER CONSTRUCTION (By kind permission of the Department of Atomic Energy).

SELLAFIELD · SPRINGFIELDS
CAPENHURST · CALDER HALL 'A'
CALDER HALL 'B' · HARWELL
CHAPELCROSS · DOUNREAY

60,000 Tons of Steelwork

UNDER DIRECT CONTRACT WITH THE U.K.A.E.A. ALEX. FINDLAY & CO. LTD., MOTHERWELL, HAVE BEEN ENTRUSTED WITH THE SUPPLY, DELIVERY AND ERECTION OF 60,000 TONS OF STRUCTURAL STEELWORK TO BUILD BRITAIN'S NUCLEAR POWER PROJECTS.

ALEX. FINDLAY & CO. LTD.

STRUCTURAL ENGINEERS

MOTHERWELL · SCOTLAND

Phone Motherwell 2301 (6 lines)

✻ *MEMBER OF THE NUCLEAR POWER PLANT CO. LIMITED* ✻

LONDON OFFICE: HIGH HOLBORN HOUSE, 52/54 HIGH HOLBORN W.C.1 TELEPHONE HOLBORN 7330-5083

A45

HEAD WRIGHTSON AT BRADWELL

Head Wrightson's field of work on the Bradwell Nuclear Power Station will be the design, supply and construction of the heat exchangers, in collaboration with Messrs. Clarke, Chapman & Co Ltd, the installation of the graphite around the reactors and also the supply of shield cooling blowdown and evacuating systems.

The Company has gained much experience in connection with the work executed on the Dido and Pluto reactors at Harwell and the research reactors for Dounreay, Australia and Denmark and their service to nuclear power industry is supported by many years of research and development work carried out in close collaboration with the United Kingdom Atomic Energy Authority.

HEAD WRIGHTSON & CO. LTD.

NUCLEAR POWER DIVISION

TEESDALE IRON WORKS THORNABY-ON-TEES

LONDON · JOHANNESBURG · TORONTO · SYDNEY · CALCUTTA

P547

CIVIL ENGINEERING & ARCHITECTURAL

DESIGN & CONSTRUCTION

of the

BRADWELL NUCLEAR POWER STATION

by

SIR ROBERT

McALPINE

& SONS

80 PARK LANE, LONDON, W.1

THE PARSONS COMPANY HAS BEEN ASSOCIATED WITH NUCLEAR POWER DEVELOPMENT SINCE 1946. THEY HAVE NOW ON ORDER OR HAVE SUPPLIED

740,000 kw turbo-generating plant

for nuclear power stations

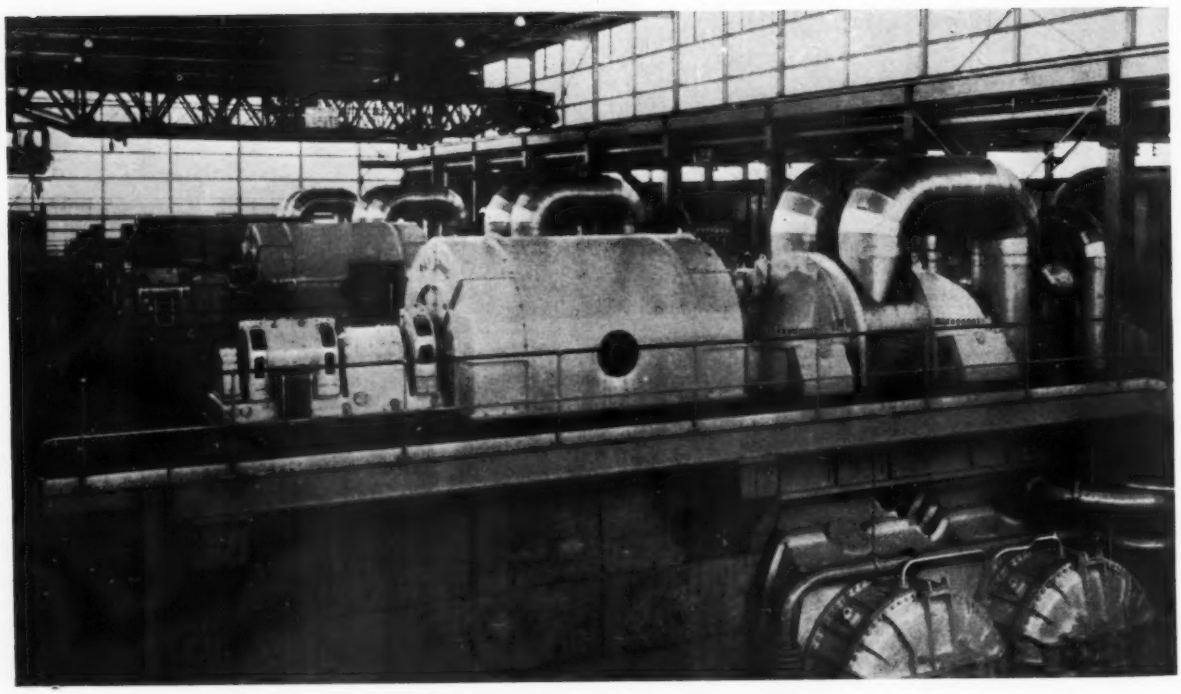
These machines are on order for — or have been installed at:

CALDER HALL 'A'

CALDER HALL 'B'

CHAPELCROSS

BRADWELL



Four Parsons turbo-generators in operation at Calder Hall 'A' nuclear power station

In addition PARSONS are supplying to Bradwell:

ALL THE CONDENSING PLANT
GAS CIRCULATORS
GAS DUCTS AND VALVES
CHARGE TUBE ASSEMBLIES
F. P. D. COMPRESSORS
INSTRUMENTATION

PARSONS

C. A. PARSONS & COMPANY LIMITED
HEATON WORKS · NEWCASTLE UPON TYNE 6

All the switchgear comprising the main 132-kV air-blast circuit-breakers, 6·6-kV, 3·3-kV, and 415-volt air-break equipment for auxiliary supplies, together with its associated control apparatus for Bradwell Nuclear Power Station is being supplied by Reyrolle who are responsible also for the reactor control-rod heads, the fission-products detection equipment, and the machining of the graphite blocks.

Reyrolle — specialists in switchgear and control-apparatus

MEMBER OF THE NUCLEAR POWER PLANT CO. LTD. NPPC

Reyrolle & Company Limited · Hebburn · County Durham · England

A49

Bradwell will use

---

nuclear fuel handling plant

---

by **Strachan and Henshaw**

(A MEMBER COMPANY OF THE NUCLEAR POWER PLANT CO LTD)

11 REACTORS WITH S & H EQUIPMENT

Calder Hall A	2 reactors
Calder Hall B	2 reactors
Chapel Cross	4 reactors
Dounreay	1 reactor
BRADWELL	2 reactors

STRACHAN & HENSHAW LTD

Designers and Manufacturers of Mechanical Handling Plant

STEELHOIST WORKS · ST. PHILIPS · BRISTOL

A50

BRADWELL

will incorporate
the 9th and 10th
NUCLEAR REACTOR
PRESSURE VESSELS
built by

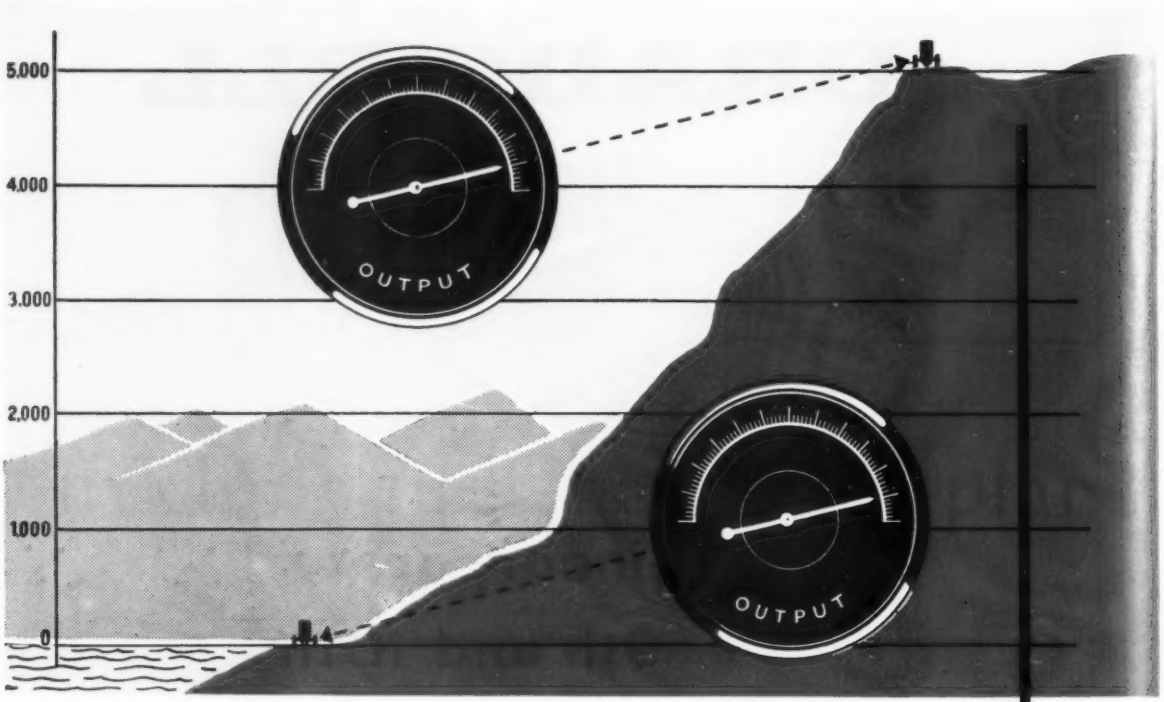
WHESSOE

Calder A	UKAEA	2 vessels
Calder B	ditto	2 vessels
Chapelcross	ditto	4 vessels
*Bradwell	CEA	2 vessels

* A NUCLEAR POWER PLANT CO. LTD. CONTRACT

WHESSOE LIMITED · DARLINGTON AND LONDON

A51



High output from low power—
from sea level to 5000 feet
—Holman portable 2-stage compressors

On the seashore or five thousand feet up in the mountains — you'll still get the same high output from a Holman portable compressor. And at low cost, because the maximum volume of air is compressed for a given power. That's one advantage of two-staging. There are others. Temperatures are lower, so a little oil goes a long way — carbon deposits are negligible, valves last longer and overhaul charges are considerably smaller. Friction is cut, too; stresses are reduced and so are the chances of breakdowns.

A Holman portable compressor gives you great operating flexibility and cuts running cost. And it's running cost that is the *real* cost of pneumatic equipment. Get a Holman and you've got the toughest most efficient and reliable *money-saving* air compressor you'll find

Hire-purchase terms can be arranged.

Holman
PNEUMATIC EQUIPMENT

pays . . . with its life

HOLMAN BROS. LTD., CAMBORNE, ENGLAND
The Holman Organisation is world-wide. It includes the Climax Rock Drill & Engineering Works Ltd., and has agents, branches and technical representatives throughout the United Kingdom and in 84 other countries.
Telephone: Camborne 2275 (10 lines). Telegrams: Airdrill, Telex, Camborne. London Office: 44 Brook Street, W.1. Telephone: Hyde Park 9444 HJ25

We are happy to be associated with the Nuclear Power Plant Company and Bradwell in this project.

The Bradwell story is one of enterprise; and Britain today depends on enterprise more than ever before in her history.

The Steel Company of Wales is particularly happy to share in this enterprise, having been awarded an order by C. A. Parsons and Company Limited, an associate company of the Nuclear Power Plant Company Limited.

High-quality silicon steel sheet from our Newport Division will be supplied for the stator cores of both main and auxiliary turbo-generators; and hot and cold-rolled electrical sheets, also from the Newport Division, will be used in many of the transformers to be built for Bradwell.

THE STEEL COMPANY OF WALES LIMITED

GKN

(SOUTH WALES) LTD.

take great pride in their association with

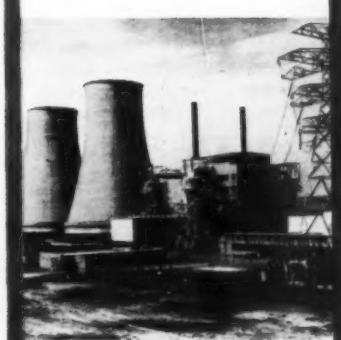
BRADWELL

Steel reinforcing bars rolled at their Cardiff works are being used extensively in this world-important project.

Guest Keen & Nettlefolds (South Wales) Ltd., Castle Works, CARDIFF

Telephone Cardiff 33033 · Telegrams, Nettlefolds Cardiff · Telex, 49-316

As at Calder Hall, m and i Electrical Insulating materials will be playing their part at Bradwell Nuclear Power Station



"PAXOLIN" & "PANILAX" are registered trade names of The Micanite & Insulators Co., Ltd.,

Left, Calder Hall by courtesy of The U.K. Atomic Energy Authority

Right, Bradwell-on-Sea Nuclear Power Station by courtesy of the Nuclear Power Plant Co., Ltd.

The Electrical Insulation People

MANUFACTURERS AND SUPPLIERS OF —

MICA in all forms.
MICANITE in all grades; sheets, cones, tubes, separators and special shapes.
"PAXOLIN" synthetic-resin bonded laminates with paper, fabric, asbestos, and other fillers, in sheets, rods, tubes and special shapes, machined, punched and moulded parts, in various grades with a variety of finishes.
HIGH VOLTAGE BUSHINGS AND TERMINALS.
"PANILAX" resin mouldings.
EMPIRE varnished insulating materials including paper, cotton, silk, Terylene, nylon and glass.
VULCANISED FIBRE sheets, rods, tubes and machined parts.
LEATHEROID in sheets, rolls, strips and punched parts.
SILICONE electrical insulation in various forms.
THERMOPLASTIC injection mouldings.
PVC & POLYTHENE extrusions.

THE MICANITE & INSULATORS CO., LTD., Blackhorse Lane, Walthamstow, London, E.17. Tel: Larkswood 5500. Tel: "Mytillite" Easphone, London

"THE BRADWELL STORY"

Illustration of Ducting

class 1 welding by

JENKINS

of Rotherham

Our contribution to nuclear power includes welded steel Constant Volume Feeders for the U.K.A.E.A; 54" dia. CO_2 ducting for Calder Hall; boiler steam drums and many other vessels in mild steel and stainless steel for Dounreay and other atomic projects.

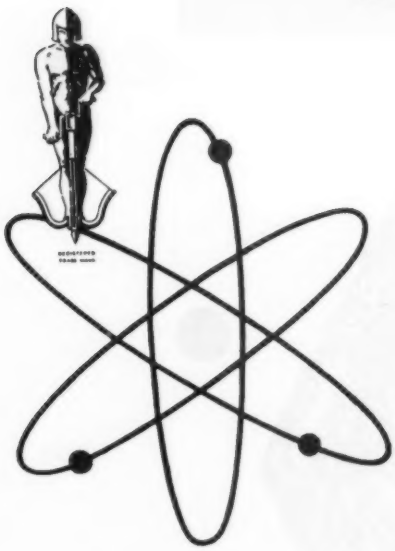
The development of atomic power demands technical knowledge and practical ability unprecedented in the progress of industry. In the construction of Britain's new power plants full advantage is being taken of Jenkins experience in Class 1 welding as evidenced by their contribution of fabricated steel ducting for the circulating gases and blower units at Bradwell, now being built by Nuclear Power Plant Co. Ltd.

THE SIGN OF GOOD WELDING

ROBERT JENKINS & CO. LTD. ROTHERHAM

Telephone: 4201-6 (6 lines)

Crane Packing Ltd. . . . .



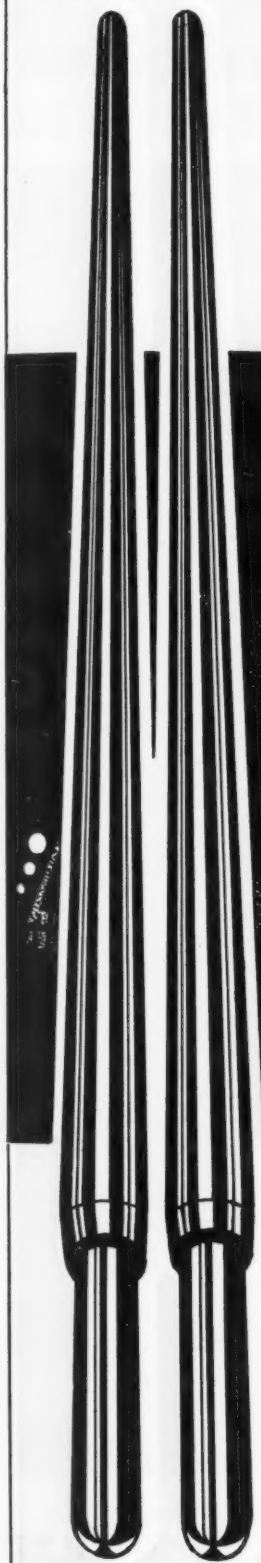
are supplying
Gland Packings
Condenser Packings
Mechanical Seals
and products of
the Company's
PTFE Engineering Division
for Atomic Energy Projects
including
the Nuclear Power Station
at Bradwell-on-Sea.

The Contractors for the Bradwell-on-Sea Nuclear Power Station, The Nuclear Power Plant Co. Ltd., are ahead of schedule on this contract, and already orders for CRANE Condenser Packings for the main and dump condensers have been placed, and for CRANE Superseal Style SS3 Gland Packings and CRANE Standard 1A Mechanical Seals, which will be in service in the various pumping units.

Crane Packing Ltd. is a member of the TI Group of Companies, and its research programme on the special problems relating to the use of the above-mentioned products on atomic energy projects is supplemented by valuable support from the TI Research Laboratories at Hinxton Hall, Cambridge.

Issued by the Engineering Division of:

Crane Packing LTD OF SLOUGH ENGLAND A TI COMPANY



SPECIAL STEELS FOR NUCLEAR POWER . . .

One of the most essential characteristics implied by the expression 'high quality' is reliability, and the construction of nuclear power plants ranks high amongst those advanced engineering projects, where any doubt concerning the materials of construction cannot be tolerated.

Hadfields have contributed in the provision of high quality alloy steels to meet the demand of reactor designers and the "Era" series of Boron Steels was developed to satisfy the special needs of neutron absorption for control purposes. These steels are also used for special shielding applications.

Hadfields have made the Control Rods for Calder Hall and Chapelcross Stations of U.K.A.E.A., incorporating "Era Boron Steels" and "Era H.L.C." special Low Cobalt Stainless Steel. "Era H.L.C." Steel has also been used in the production of a number of other reactor components and is of the 18/8 Stabilised type.

Pressure vessel and heat exchanger forged flanges are made in special "Era C.R." and "Hecla" Steels, and a large number of small castings can be produced in our foundries which are specially equipped for this class of work.

HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS, SHEFFIELD, ENGLAND.

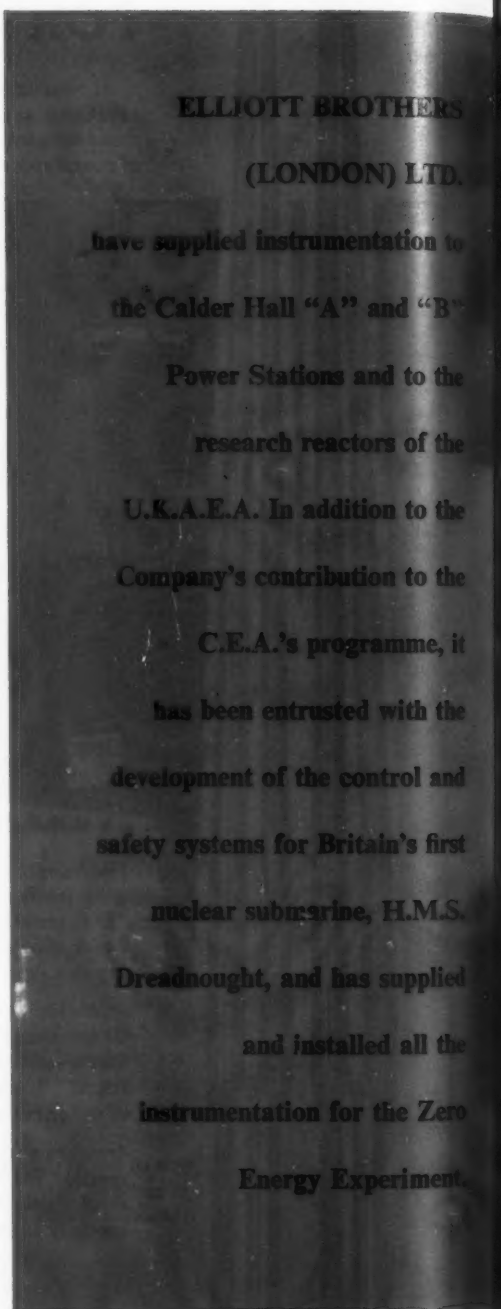
ELLIOTT

AND THE Bradwell Story

The safe and efficient operation of Bradwell will depend to no small extent on the reliable indications and control functions of instrumentation installed at all stages from the reactors to the station output.

We are honoured to be associated with the Nuclear Power Plant Company in this great venture. Our engineers have been able to help in the solution of many problems, and in some cases new instruments have been evolved.

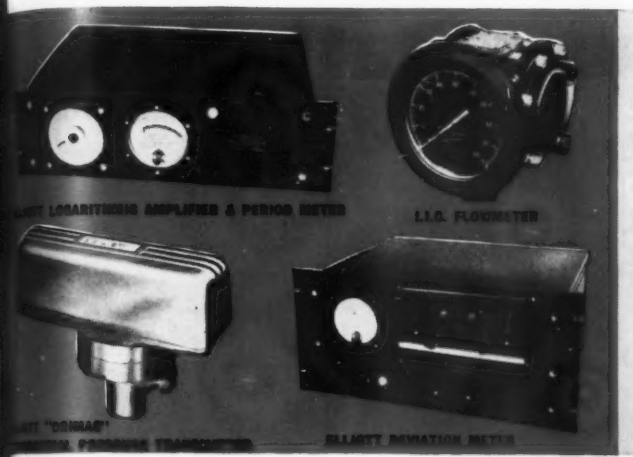
The facilities of our Nuclear Division for research, development and production, backed by the accumulated experience of our many other specialist Divisions, enable us to undertake this type of work in a manner unsurpassed by any other organisation.



ELLIOTT BROTHERS (LONDON) LTD. have supplied instrumentation to the Calder Hall "A" and "B" Power Stations and to the research reactors of the U.K.A.E.A. In addition to the Company's contribution to the C.E.A.'s programme, it has been entrusted with the development of the control and safety systems for Britain's first nuclear submarine, H.M.S. Dreadnought, and has supplied and installed all the instrumentation for the Zero Energy Experiment.

COMPLETE INSTRUMENTATION FOR NUCLEAR POW

THE COMPLETE RANGE AVAILABLE FROM ELLIOTT BROTHERS (LONDON) LIMITED INCLUDES:

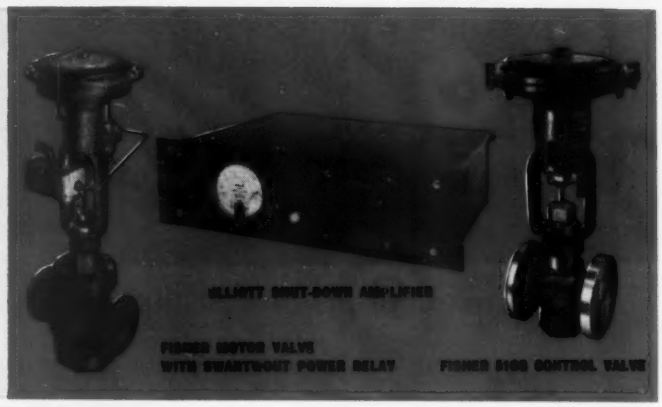


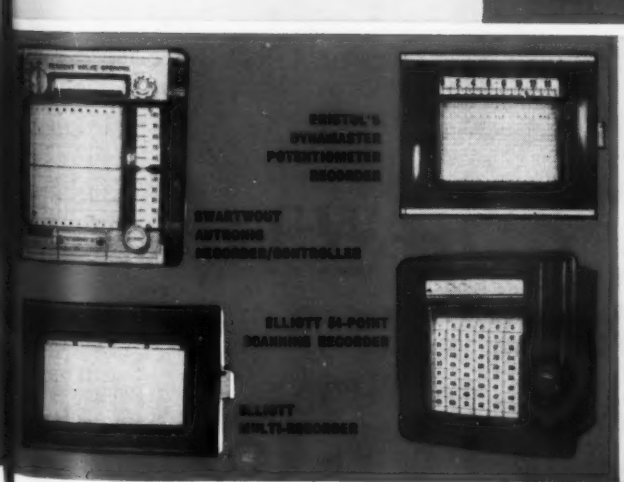
FOR MEASUREMENT AND TRANSMISSION

Linear and logarithmic amplifiers, resistance thermometers, thermocouples, pressure and level gauges, flowmeters, differential pressure transmitters.

FOR CONTROL

Shut-down amplifiers, safety and interlock circuits, electronic and pneumatic controllers, control valves, control rod servos.





FOR INDICATION AND RECORDING

Fission product monitoring equipment, miniature electronic and pneumatic recorders, recording voltmeters and milliammeters, electronic potentiometer recorders, long scale and edgewise switchboard instruments.

EA POWER STATIONS

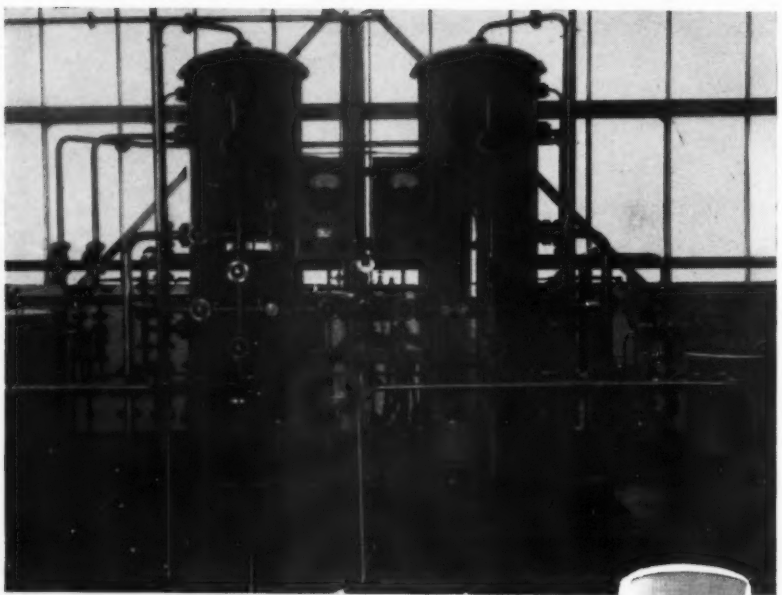
ELLIOTT

Elliott Brothers (London) Ltd., Century Works, London, S.E.13 (Tideway 1271)

THE BRADWELL STORY

Permutit

In Atomic Power Stations



CALDER HALL A

CALDER HALL B

BRADWELL

DOUNREAY

The quality of "Deminrolit" Treated Feed Water at Calder Hall A, and Calder Hall B, Atomic Power Stations is:—

Less than 1 p.p.m. dissolved solids.
Less than 0.02 p.p.m. Silica.
Conductivity less than 0.2 gemmhos.

Other Atomic Power Stations under construction are being fitted with "Deminrolit" Plant supplied by The Permutit Company Ltd.

For further details write to:—

THE PERMUTIT COMPANY LIMITED

DEPT. C.L. 294 · PERMUTIT HOUSE · GUNNERSBURY AVENUE · LONDON · W.4

Telephone CHIswick 6431

S&L

STEEL TUBES
AND MANIPULATED PIPEWORK
FOR NUCLEAR POWER STATIONS

Britain's nuclear power stations incorporate large quantities of Stewarts and Lloyds' steel tubes and manipulated pipework.

BRADWELL POWER STATION

For this new plant we are supplying, as sub-contractors to C. A. Parsons & Co. Ltd., the integral pipework associated with the twelve heat exchangers, comprising high and low pressure steam, feed and circulating pipework, together with all blowdown, drain and safety valve escape pipework and supporting arrangement.

Stewarts and Lloyds design, manufacture and install pipework for all types of industrial plants.

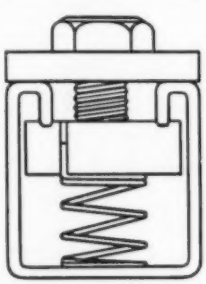
STEWARTS AND LLOYDS LIMITED

GLASGOW · BIRMINGHAM · LONDON

The largest manufacturers of steel tubes in Europe

THE BRADWELL STORY

As rigid as it looks



BOX-SECTION STRENGTH

12 or 16g. cold-rolled Unistrut channel and serrated self-locating nut bind together into a rigid, *positive* assembly (cross-section view).

and far quicker on the job

This is Unistrut—the rigid, channel support system that cuts your on-site costs because it's specially designed for rapid assembly. No drilling, no welding; no special skills or tools required. Here it is used to support a heavy run of cable : next time, perhaps, for pipes in a service tunnel, for trunking fluorescents in a big factory, or for storage racking in the contractor's own yard. It's versatile, with a full range of channel and fittings for every purpose. It's strong. And above all, it's fast. Send for the technical literature and you'll see why.

UNISTRUT STEEL CHANNEL FRAMING SYSTEM

FOR PIPE, CABLE, AND CONDUIT SUPPORT, ELECTRICAL TRUNKING, HEAVY-DUTY ADJUSTABLE RACKING, LOW-COST PARTITIONING, ETC.

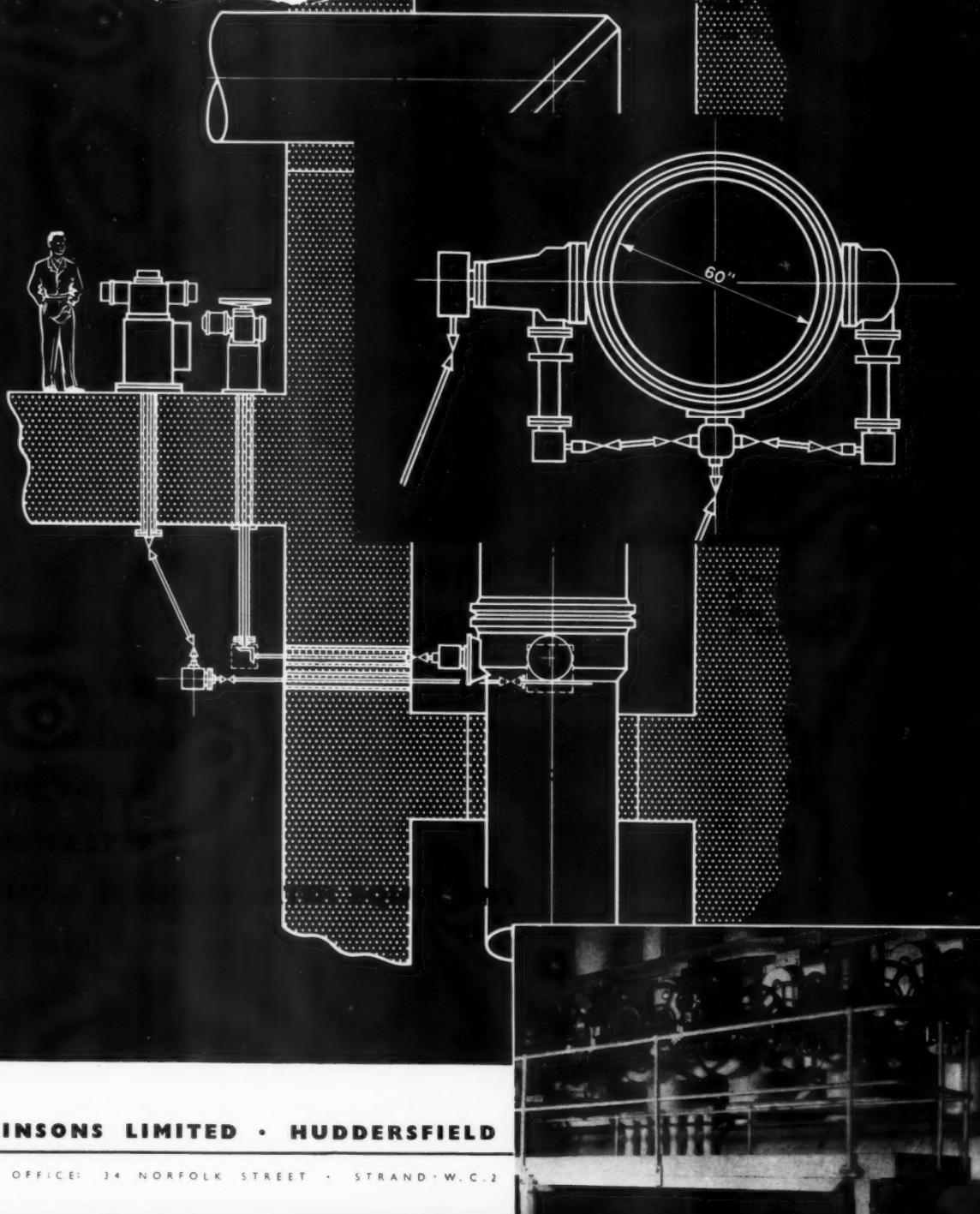
UNISTRUT DIVISION OF SANKEY-SHELDON LTD., DEPT. NP8, 46 CANNON STREET, LONDON, E.C.4
TELEPHONE: CITY 4477. TELEGRAMS: SANKESHEL, CANNON-LONDON

UNI 9061

FROM REACTOR TO TURBINE

the valves at Bradwell are

HOPKINSONS



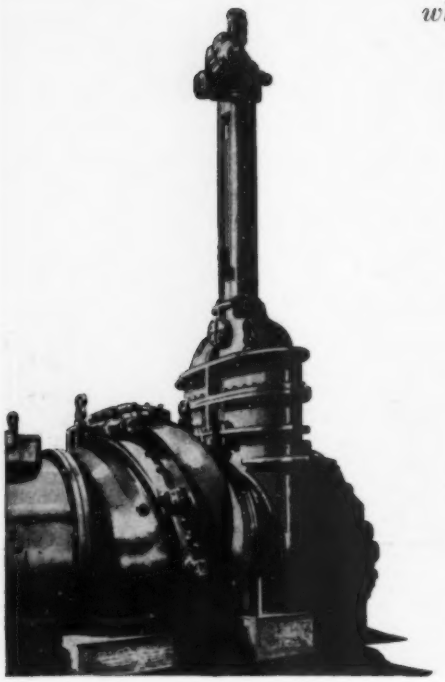
HOPKINSONS LIMITED · HUDDERSFIELD

LONDON OFFICE: 34 NORFOLK STREET · STRAND · W.C.2

THE BRADWELL STORY

Blakeborough Valves for

BRADWELL



Orders have been placed with us by the Nuclear Power Plant Co. Ltd. and constituent firms covering the whole of the main circulating water valve equipment for this important undertaking. They include a total of 68 electric motor operated sluice valves in sizes up to 54 in. diameter, for pumping plant and condenser connections; large motor operated penstocks; 54 in. diameter multiple door pump non-return valves of Blakeborough patent Free-acting pattern; 30 in. diameter manually operated butterfly valves with rubber seating for tight shut-off; together with a wide variety of types for other auxiliary services. Backed by long experience as one of the leading suppliers of valves for central power stations, we are now extensively engaged on work for nuclear power projects, involving, in addition to our established lines, the production of special types for reactor coolant and other applications on the nuclear engineering side.

BLAKEBOROUGH

J. BLAKEBOROUGH & SONS LTD., BRIGHOUSE, YORKSHIRE

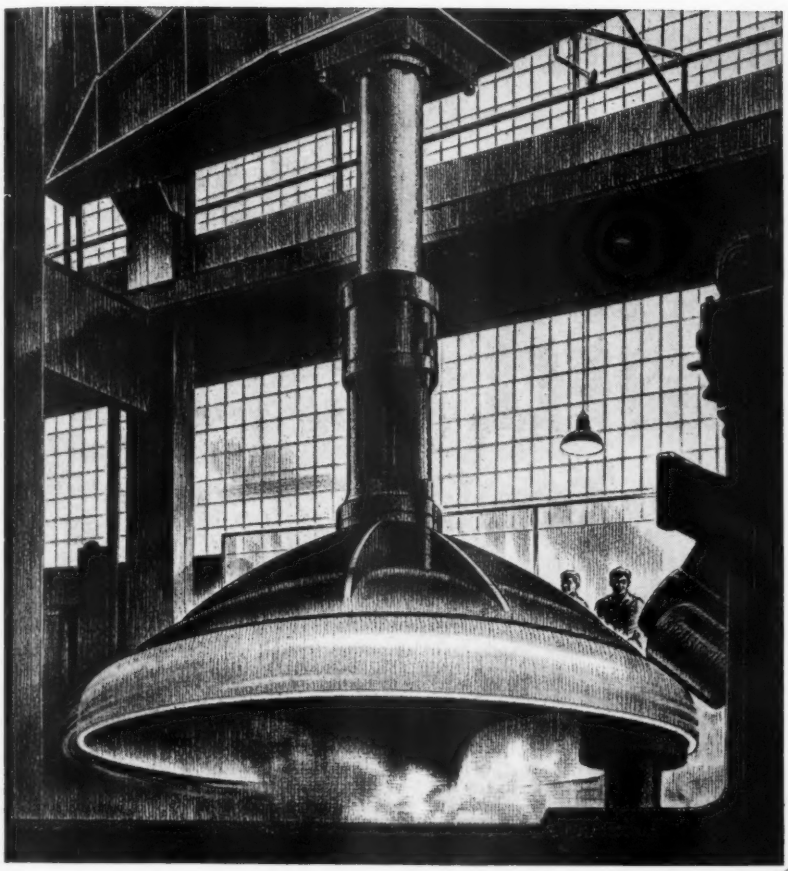
blb10126

THE BRADWELL STORY

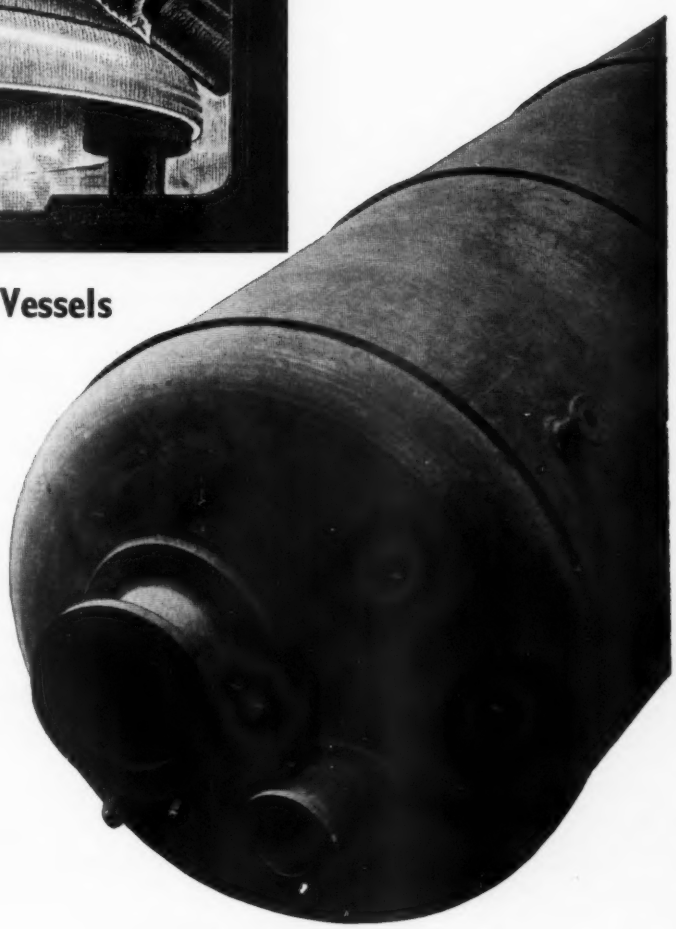
Spinning

SAVES METAL

—CUTS TOOL COSTS



The design and production of Pressure Vessels may be greatly facilitated by using dished and flanged ends spun by Harveys on the Rotarpress. They combine semi-ellipsoidal form with large knuckle radius. A substantial reduction in plate thickness can be effected, and in most cases tool costs are eliminated.



'Rotarprest' Ends for Pressure Vessels

can be supplied in Mild, Alloy and Clad Steels and Non-ferrous Metals. The capacity of the Rotarpress ranges from 5 to 15 feet diameter, and $\frac{3}{8}$″ to 4″ thickness. Knuckle radii and depth may be varied to meet individual requirements.

Please ask for List No. NP 965 giving full range of sizes.

Harvey

G. A. HARVEY & CO. (LONDON) LTD.
WOOLWICH ROAD - LONDON, S.E.7

Telephone: GREenwich 3232 (22 *lines*)

BOBY

Water Treatment Plant

has been selected by the

Nuclear Power Plant Co. Ltd.

for installation in the

BRADWELL

Nuclear Power Station as follows:

1 Base exchange treatment for the feed water requirements of the temporary Economic boilers used for the construction of the power station. When the need for this supply ceases, the Boby Plant will be available for other permanent duty.

2 Equipment for chemically dosing the circular cooling water of blower cooling circuits to inhibit corrosion and prevent scale deposition. The treatment will be the addition of controlled doses of tannin, phosphate, sodium carbonate, into a closed circuit for the maintenance of the necessary number of concentrations in the cooling water circuit.

Specialists in the design of:

WATER
BOBY
TREATMENT

SOFTENERS
Hot Lime-Base Exchange
Hot Lime-Soda-Phosphate
Base Exchange—Manual and Automatic

DEMINERALISERS
2 and 3 Bed Systems
Mixed Bed

CHEMICAL DOSING EQUIPMENT
Proportional Dosing Plant
Intermittent Dosing Plant for conditioning feed water, cooling water circuits for steam and oil etc.

COAGULATION AND COLOUR REMOVAL

DEAERATORS Heating and Vacuum Types

WILLIAM BOBY & CO. LTD.
RICKMANSWORTH, HERTFORDSHIRE, ENGLAND
Tel: Rickmansworth 4251*

BRADWELL POWER STATION

The Unit Superheater and Pipe Co. Ltd., following initial contracts for reactor charge tubes for Calder Hall and Chapelcross power stations, has been entrusted by Whessoe Limited, member company of the Nuclear Power Plant Co., to produce the charge/discharge and control rod stand pipes for Bradwell Power Station.

'Unit' has laid down a production line capable of achieving the precision assembly and high standard of welding to manufacture these tubes to the close tolerances required. The photographs show stages in welding using low hydrogen electrodes throughout. All welds are ground flush externally and the bores dressed smooth. In accordance with Lloyds' requirements over 6,000 films will be needed to cover the radiographic examination of the welds.

WELDING

DRESSING

RADIOGRAPHY

THE UNIT SUPERHEATER AND PIPE COMPANY LIMITED

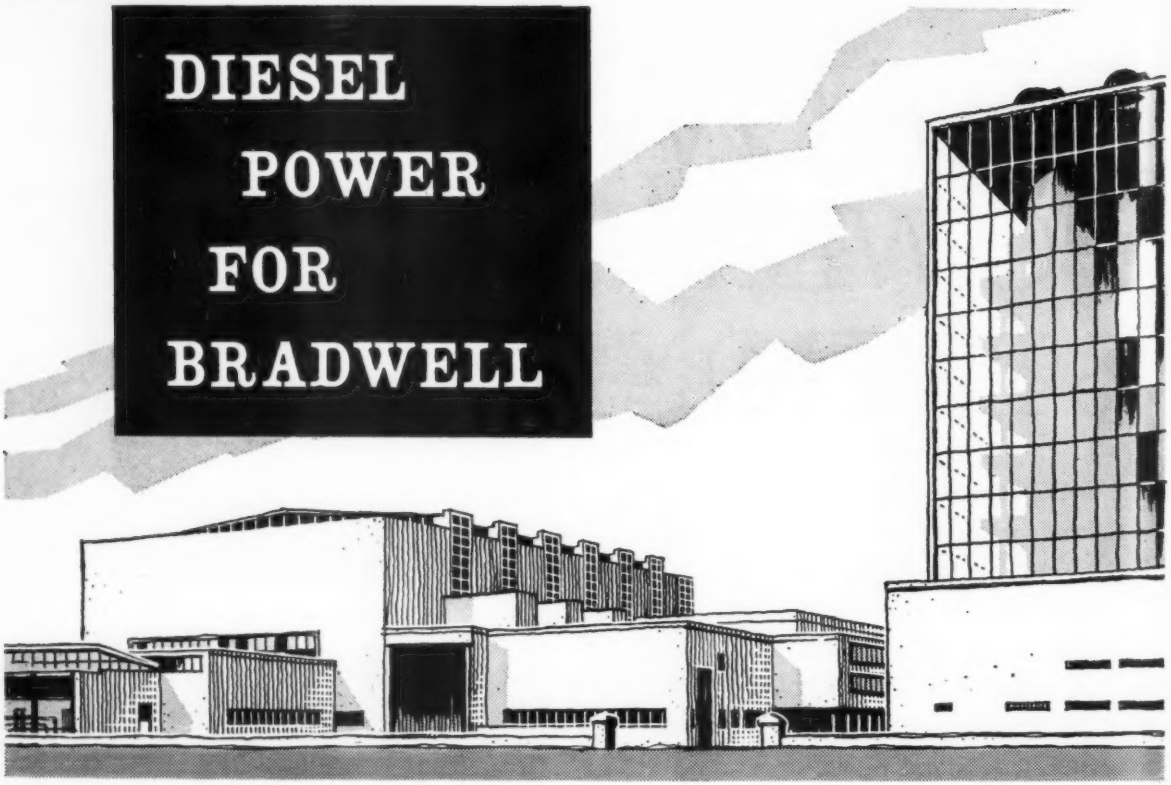
UNIT WORKS, SWANSEA.

Telephone: Swansea 54091 (6 lines).
Telegrams: 'Superunits', Swansea. Telex: 48-208.

UNIT

THE BRADWELL STORY

DIESEL POWER FOR BRADWELL



CROSSLEY engines for essential duties

Crossley Diesels have been chosen for yet another new nuclear power station, at present being constructed by the Nuclear Power Plant Company. Engines of the same design are in service or being installed in the United Kingdom Atomic Energy Authority's power stations at Calder Hall "A" and "B", Chapel Cross and Dounreay.

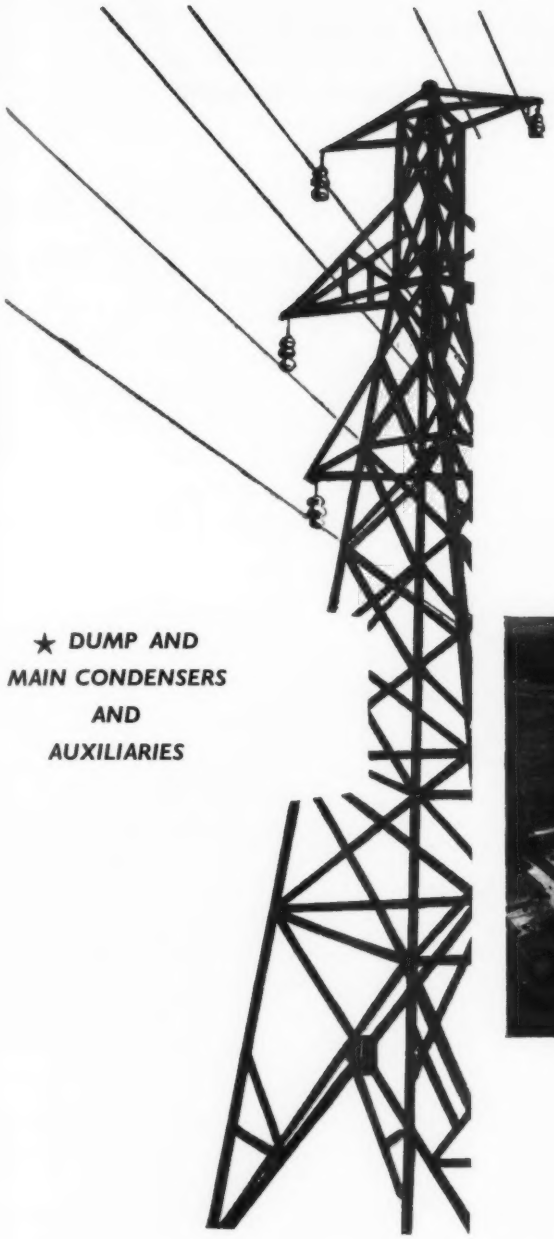
Permanently installed will be three Crossley "ES Vee" 10 cylinder two-cycle Scavenge Pump Diesel engines, each rated at 620 b.h.p. at 1000 revolutions per minute and driving 450 kW. Lancashire Dynamo and Crypto alternators. These are automatic standby sets for the provision of current for essential services in the event of mains failure. The sets are supplied for Bradwell to Messrs. A. Reyrolle and Co. Ltd.

Already installed on site is an "HSN 6" six cylinder two-cycle engine driving a 412 kW. alternator, this unit providing power on site during the construction period. Later two Goliath cranes will be installed, each powered by an "HSN 3" three cylinder straight line two-cycle Scavenge Pump Diesel engine driving Clarke Chapman 250 kW. alternators, one unit being mounted in one of the legs of each crane. These two sets are being supplied to the order of Messrs. Clarke Chapman & Co. Ltd.

CROSSLEY DIESEL ENGINES

CROSSLEY BROTHERS LIMITED · OPENSHAW · MANCHESTER 11

℗C423



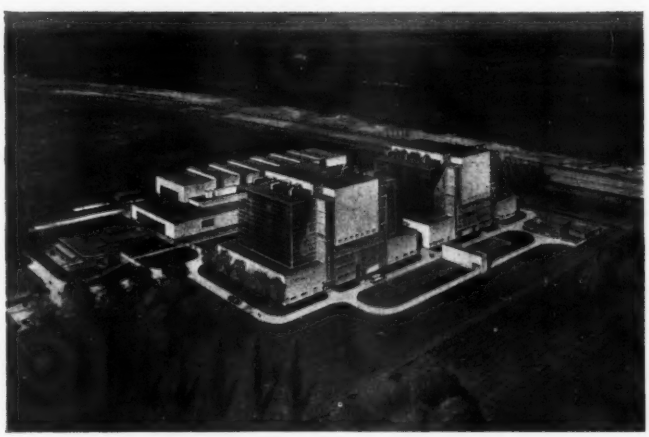
★ DUMP AND MAIN CONDENSERS AND AUXILIARIES

★'BATALBRA' TUBES

★'BATNAVAL' PLATES

Chosen for

BRADWELL



A major supplier for —

First — **CALDER HALL B**

Second — **CHAPEL CROSS**

and NOW — **BRADWELL**

with nearly 100 tons of **'BATALBRA' TUBES** and a considerable tonnage of **'BATNAVAL' PLATES.**

BATTERY

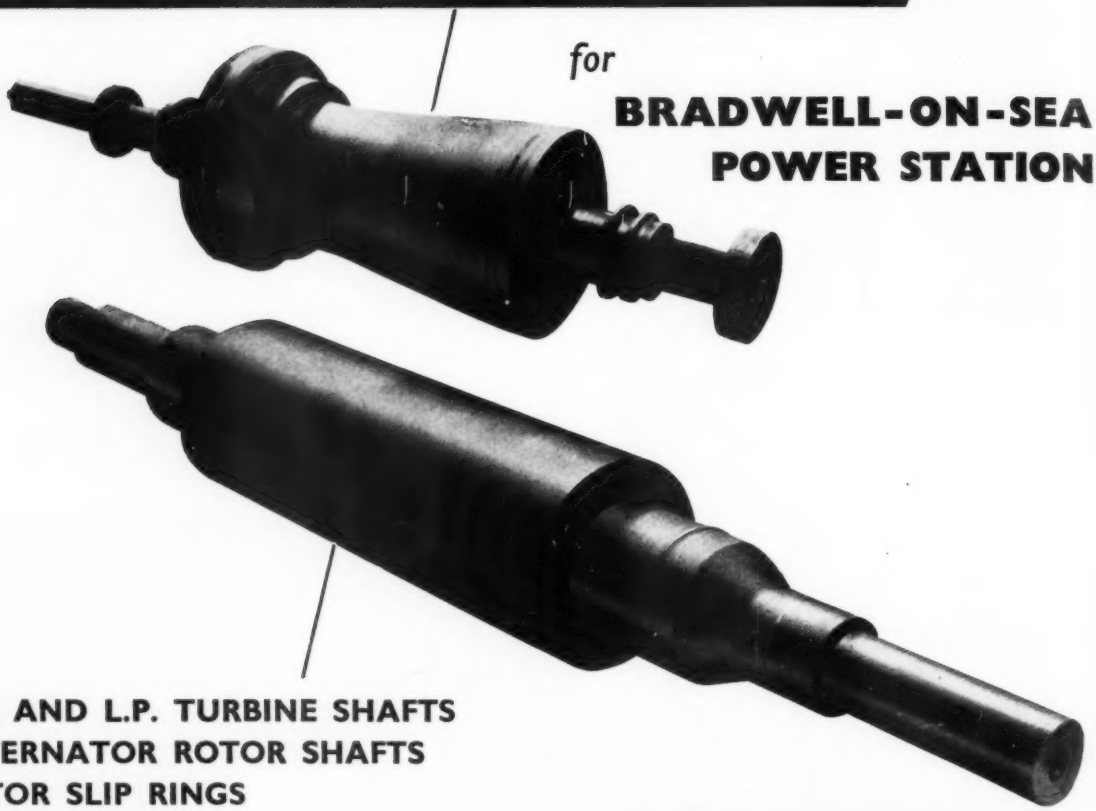
The BIRMINGHAM BATTERY and METAL CO LTD

SELLY OAK BIRMINGHAM 29

Over a Century of Independent Enterprise

THE BRADWELL STORY

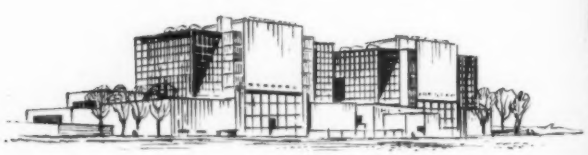
FORGINGS IN SPECIAL ALLOY STEELS

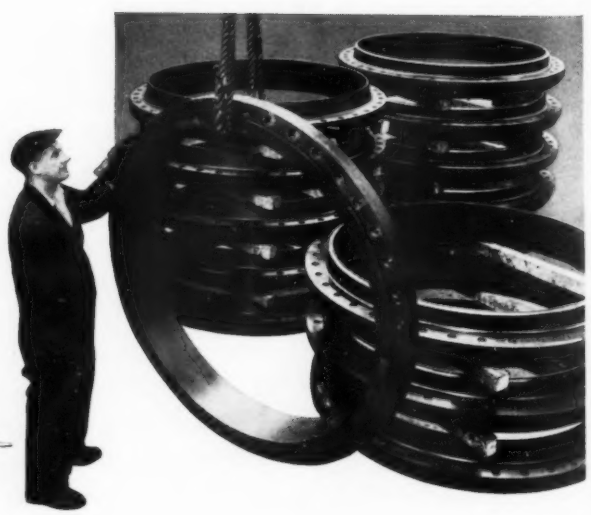


for

BRADWELL-ON-SEA POWER STATION

H.P. AND L.P. TURBINE SHAFTS
ALTERNATOR ROTOR SHAFTS
ROTOR SLIP RINGS
ROTOR END CAPS
FAN COVER PLATES
FAN BACK PLATES
OIL SEAL FORGINGS
HYDROGEN SEAL RINGS
FLANGES
GEARING FORGINGS





by

FIRTH BROWN

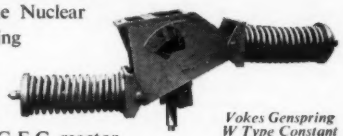
ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

A70

Vokes Genspring chosen for Pipe Suspension at Bradwell

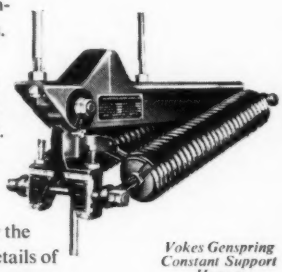
Vokes Genspring Limited are proud to announce that they have been awarded the contract for the supply of Constant Support Hangers for the main CO^2 gas lines and ancillary equipment for the Nuclear Power station at Bradwell, now being built by Nuclear Power Plant Co., Ltd. Genspring Support Hangers have also been ordered for the A.E.I.-John Thomson reactor at Berkeley and the G.E.C. reactor at Hunterston. At Calder Hall and Chapelcross, Genspring Hangers are already at work.



Vokes Genspring W Type Constant Support Hanger

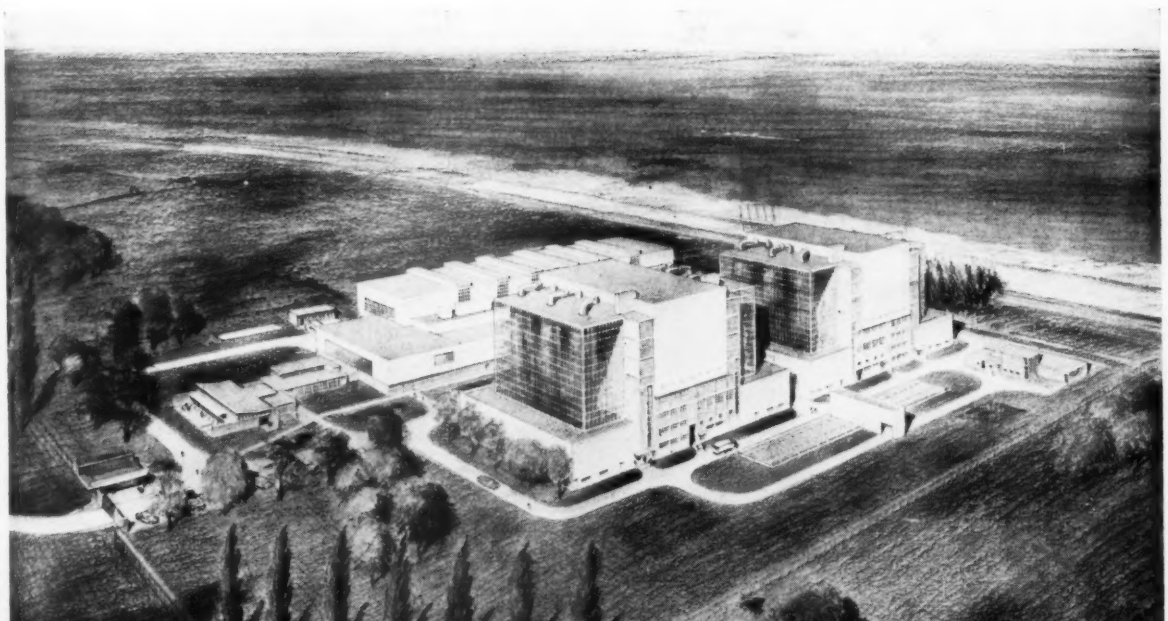
Controlled support is always important — especially where pipes are concerned. Where pipe lines are subjected to high temperature, freedom from weight-stress is substantially increased by installing Genspring Constant Support Hangers. These provide constant support to a load of up to 30,000 lbs. over a range of movement up to 12″.

Where less accurate control of stresses is acceptable, Vokes Genspring Variable Support Hangers compensate for vertical movement. With rated loads up to 5,418 lbs, they give a wide selection of support up to a maximum of 6″ spring deflection.



Vokes Genspring Constant Support Hanger Model H.12

If you have pipe suspension problems, send for the Vokes Genspring Catalogues. They give full details of each method and will help you select the type of suspension most suited to your particular requirements.



Artist's impression of Bradwell, Britain's first commercial nuclear power station

VOKES GENSPRING

SUSPENSION SYSTEMS

VOKES GENSPRING LIMITED • GUILDFORD • SURREY

VG18

Electric Motors and Generators—

Electric Motor Driven Centrifugal Pumps

for Atomic Power Stations

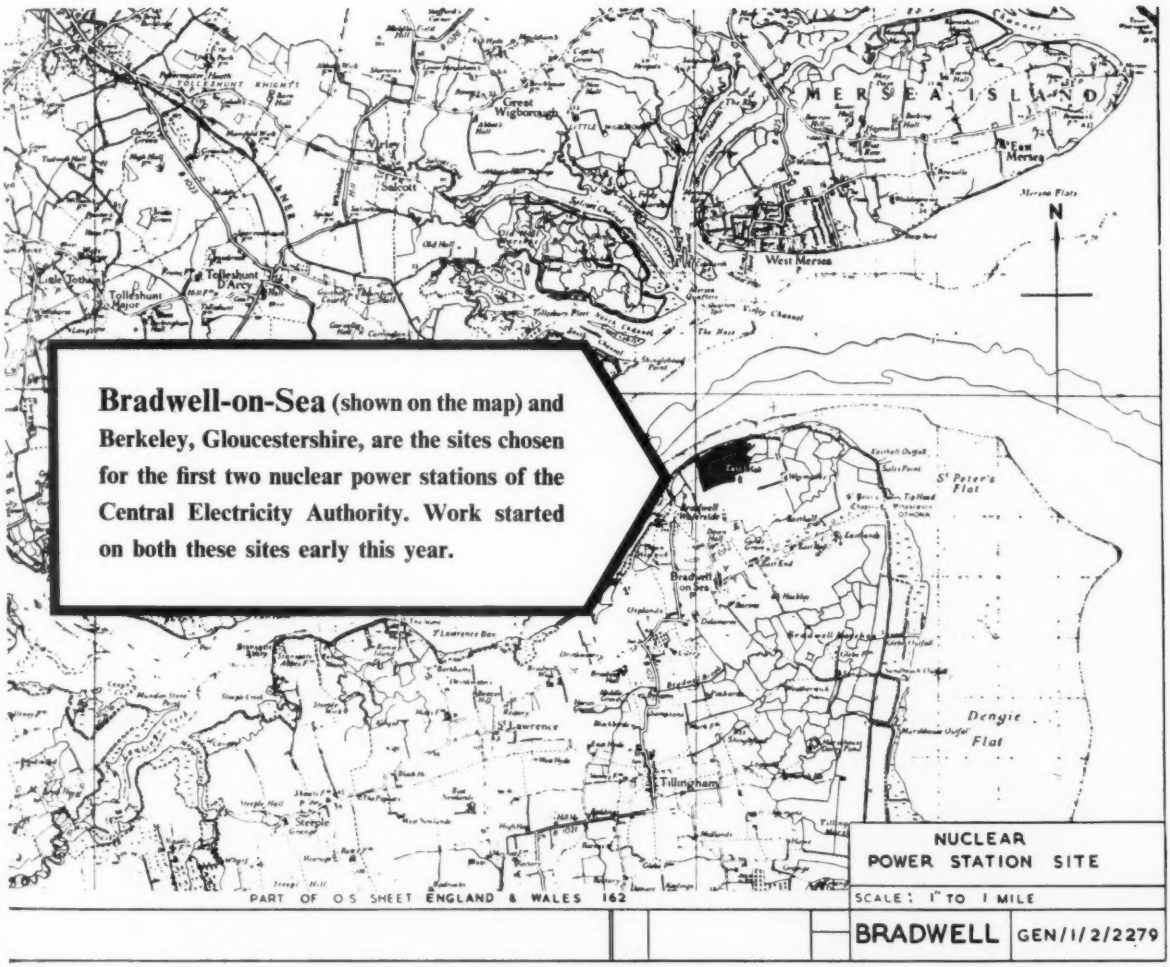
Illustration shows one of the Mather & Platt Ward-Leonard sets feeding main blower motors at Calder Hall and Chapelcross Power Stations. These were supplied under sub-contract to C. A. Parsons & Co. Ltd., Newcastle-upon-Tyne. Mather & Platt Ltd. are also supplying electrical and pumping equipment for Bradwell Power Station under sub-contract to The Nuclear Power Plant Co. Ltd.

Mather & Platt
LIMITED

PARK WORKS, MANCHESTER 10

Telephone: COLlyhurst 2321 Telegrams: Mather, Manchester

Electricity from Nuclear Energy



Bradwell-on-Sea (shown on the map) and Berkeley, Gloucestershire, are the sites chosen for the first two nuclear power stations of the Central Electricity Authority. Work started on both these sites early this year.

Crown Copyright Reserved

The growing need for power

As Britain's industrial efficiency increases, so does the need for power. The demand for power doubles every ten years; supplies of home-produced coal do not keep pace with these developments. Nuclear energy and oil will make up the discrepancy between the demands for electric power and the available coal supplies.

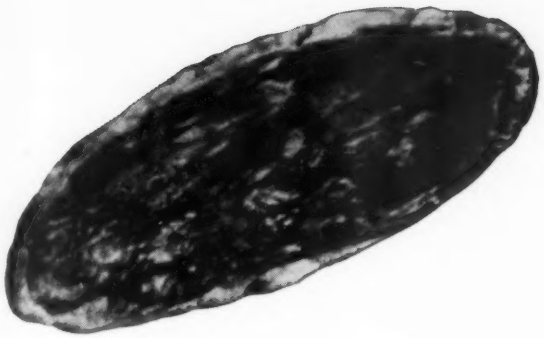
Central Electricity Authority has placed contracts for two nuclear power stations, sited at Bradwell in Essex, and Berkeley in Gloucestershire. A third station—the largest yet projected—is to be erected at Hinkley Point near Bridgwater in Somerset. These three stations will have an aggregate capacity of some 850,000 kilowatts.

The Government's revised nuclear power station programme provides for 19 nuclear power stations to be completed by 1965. They will develop from 5,000 to 6,000 megawatts of capacity and add to the national power resources the equivalent of some 18 million tons of coal a year.

As the demand for power grows, nuclear energy will become more and more important as a source of electric power, upon which the economic future of the country so largely depends.

CEA

TALBOT STEAD TUBE COMPANY LIMITED · GREEN LANE · WALSALL · A TI COMPANY



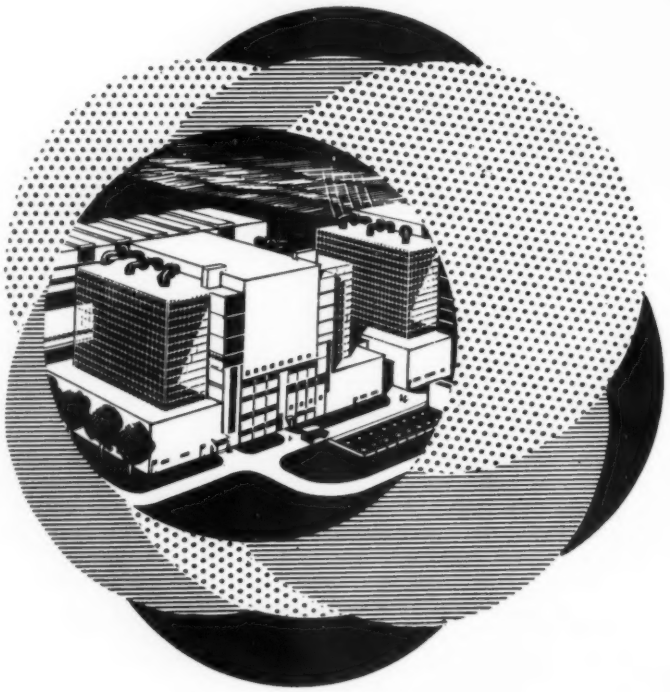
Janet needs to be a few years older before she is as skilled with the frying pan as is her mother, and by then she will be enjoying the great benefits to be derived from unlimited electric power. The atomic power stations now projected are giant signposts pointing forward towards the new age that is now almost within counting distance. Talbot Stead have a large part to play in this exciting development. Their work is not spectacular, rather is it concerned with intricate detail, but already it has reached formidable proportions. They have produced 250 miles of "snifter" tubing for Calder Hall, and every inch was made to the most exacting standards; 60 miles of stainless steel tubing in various sizes was made to the requirements of John Thompson (Wolverhampton), Ltd., for Dounreay; and, among a wide range of other parts, over one million stainless steel Raschig rings. Fortunately Talbot Stead's pioneer work, not only in the production but also the manipulation and fabrication of stainless steel tubes, is now proving its great potential value. They are equipped to co-operate with designers in planning new stations of even greater capacities than anything yet projected.

Talbot Stead TUBES FOR ATOMIC ENERGY

Talbot Stead are proud to announce that they have been awarded contracts by C. A. Parsons & Co. Ltd. to supply the following reactor components for the Bradwell Nuclear Power Station: Short Charge Plugs, Absorber Rods, Fuel Element Support Assemblies, Control Rod Standpipe Plug Assemblies, Control Rods, Control Rod Standpipes, Charging Standpipes, Neutron Source Assemblies.

MANUFACTURERS OF: CARBON, ALLOY AND STAINLESS STEEL TUBES · BI-METAL TUBES · 'FORJEND' STAINLESS WELDING FITTINGS · 'METIOR' SANITARY PIPE FITTINGS MACHINED FLANGES AND COMPONENT PARTS · 'METICA' METAL CLAD CARBON AND GRAPHITE TUBES · CARBON, ALLOY AND STAINLESS DRAWN AND GROUND BARS AND WIRE

TBW/15



BRADWELL will use SHELL Atomic Power Lubricants

At their Thornton Research Centre, Shell have carried out long-term experimental work using their own cobalt source of irradiation. Calder Hall has provided practical experience of working conditions. The result is a range of Atomic Power Lubricants* which will be used at the new Bradwell Nuclear Energy Power Station operated by the C.E.A. This range is now available to the whole Atomic Power industry.

*** The Shell A.P.L. Range is another proof of Leadership in Lubrication.**

SHELL

Publishers Column

THE FACTS OF LIFE

We here at NUCLEAR POWER have started this column so that we can have a small corner from which to tell you, our reader, about some of the strange and exciting things that happen in the process of getting this magazine to you every month.

A few days ago at the Engineering, Nuclear Energy Exhibition at Olympia, London, an upstanding gentleman in a grey pin-stripe suit strolled over to our stand and started to thumb his way through issues lying on the counter. With apparently great reluctance his hand went deep down into his pocket and up came 3/6d. He'd take the latest issue, he said. Then he started at us. Nothing but advertising in this magazine—disgraceful.

Now, the publishing facts of life are these: in this issue we are giving him fifty pages of editorial, a spectacular coloured drawing of Bradwell and a data sheet on Beryllium—surely tremendous value for 3/6d, when the real cost of producing this issue is well over 10/- per copy. If he buys NUCLEAR POWER from a newsagent we get very much less than 3/6d anyway since we must give a discount to the newsagent.

So, Sir, we think you should thank the advertisers from the bottom of your heart—if it was not for them you would perhaps pay £1 per copy and not the 3/6d you parted with so grudgingly. Besides, their wares and services portrayed amongst the advertising pages are Britain's nuclear shop window. Don't you ever go window shopping? It can be fun and highly instructive sometimes. You might even send them a 'thank you' Christmas Card now that we have explained one of the inscrutable mysteries of modern publishing economics.

Nuclear Power

THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

OCTOBER 1957 VOLUME 2 NUMBER 18

EDITOR
William Davidson, MSc, DIC

CONSULTANT EDITOR James F. Hill, BSc, *HARWELL*
INSTRUMENTATION EDITOR Denis Taylor, BSc, PhD, MIEE, FInstP
METALLURGY EDITOR Prof. J. Geoffrey Ball, BSc, FIM, *LONDON UNIVERSITY*
ISOTOPES EDITOR Alfred Maddock, MA, PhD, DIC, *CAMBRIDGE UNIVERSITY*
ADVERTISEMENT DIRECTOR
Harry T. Kane

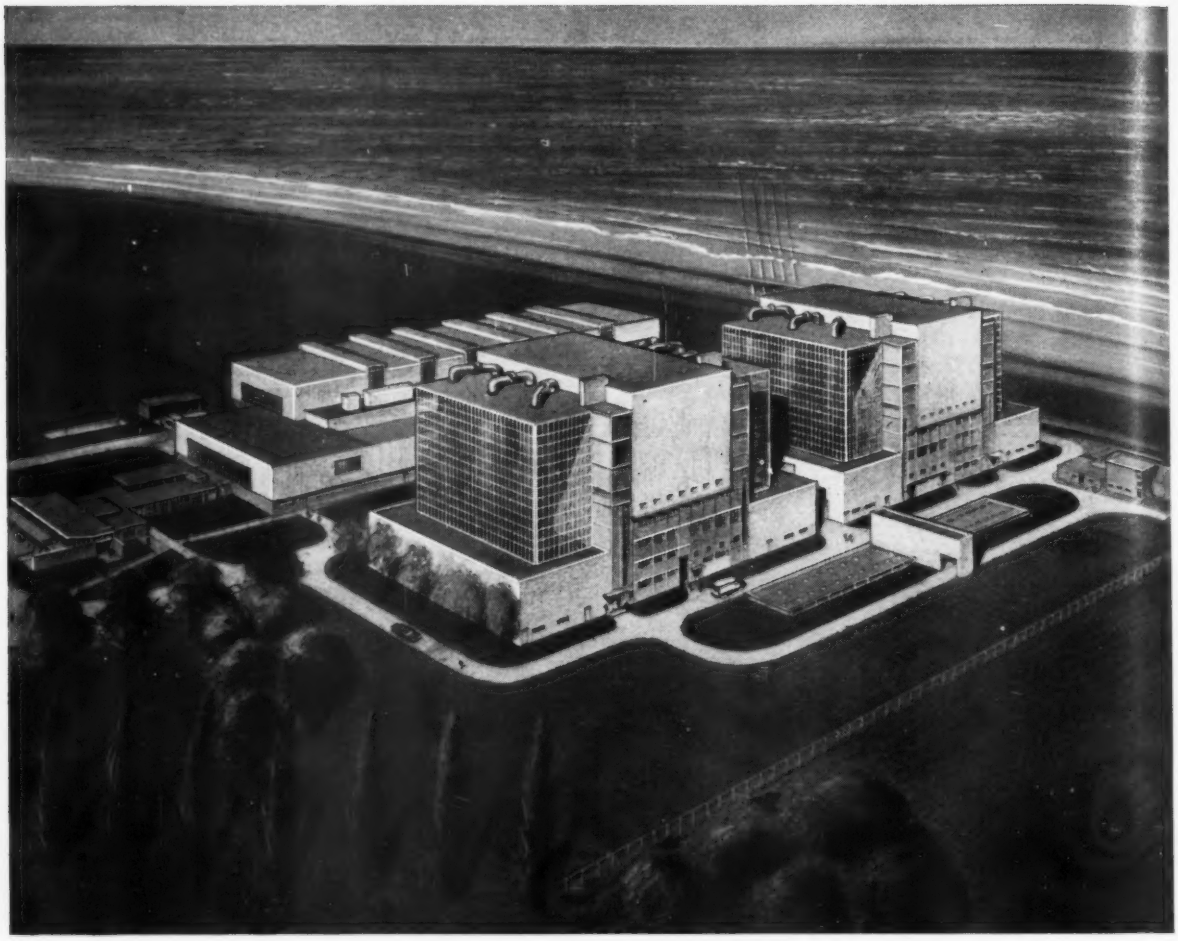
Special Bradwell Issue

CONTENTS

Editorial		395
Worldview		397
Bradwell	*Sir Claude Gibb*	401
Bradwell: Civil Engineering	*A. Houghton Brown*	403
Bradwell: Pressure vessels	*R. F. Bishop*	406
Bradwell: Progress report		408
Bradwell: General description of station		410
Bradwell FULL COLOUR DRAWING	facing	412
Bradwell: Nuclear Physics	*S. E. Lewis*	414
Bradwell: Boiler Design	*F. Carr*	416
Bradwell: Integron tubing	*F. Howarth*	420
Bradwell: Turbines and blowers		422
Bradwell: Layout of station	*T. Andrews*	424
Bradwell: Boilermaking		426
Bradwell: Special lubricants		427
Bradwell: Industry's share		429
Bradwell: List of contractors		436
Beryllium (concluded)	*G. L. Miller*	438
Beryllium Data Sheet	facing	438
Companies		441
Institutions		443
Research Reports, Names in the News		444

The entire contents are protected by copyright in Great Britain and all the countries signatory to the Bern Convention; nothing therefrom may be reproduced in any manner without the written permission of Rowse Muir Publications Limited. Nuclear Power must not, without the consent—in writing—from the publishers, be re-sold, lent, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover, by way of trade, or annexed to or as part of any other publication or advertising, literary or pictorial matter whatsoever. Special attention is called to the fact that your acceptance of this magazine with notice of the above terms constitutes a contract upon these terms between you and the person who sold it or supplied it. Subscriptions to publishers Rowse Muir Publications Ltd. Single copies UK 3/6 plus 7d postage, 5/6 overseas, 75c US and Canada. Per annum £2.2.0 U.K, £3.3.0 overseas, $8.0 US and Canada. Post free.

ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W1, MUSEUM 8252



Bradwell Nuclear Power Station

This illustration is an artist's impression of the Bradwell Nuclear Power Station, which is to supply electricity to the National Grid. All hydrographic survey work in connection with this project was carried out by Kelvin Hughes on behalf of the Consulting Engineers: Messrs. Rendel, Palmer & Tritton, acting for the Central Electricity Authority.

Hydrographic surveys of every description are undertaken by Kelvin Hughes. Their specialist Surveyors, using the most modern equipment, are available for surveys anywhere in the world.

KELVIN HUGHES

CONTRACT SURVEY SECTION

KELVIN & HUGHES (MARINE) LIMITED · 99 FENCHURCH STREET · LONDON E.C.3

TGA KHM84

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING
OCTOBER 1957 VOLUME 2 NUMBER 18

Work for thousands

THE BUILDING of one of Britain's new nuclear power stations such as Bradwell is likely to involve ultimately about a thousand firms, according to Sir Claude Gibb when he spoke in London recently. Many, in fact most, of these will be supplying products differing in no way whatever from their standard article but the fact remains that this scale of national effort is necessary to construct a nuclear power station. Five big contracting groups are now in the central nuclear power station business, not to mention those interested in package and propulsion reactors, so it can be seen that the fulfilment of the Mills programme is clearly going to involve several thousands of British firms in some way or other. The impact of nuclear energy is thus immediate and practical.

Evidence for this was abundant at last month's Engineering and Nuclear Energy Exhibition in London where enquiries at NUCLEAR POWER's stand showed beyond doubt the eagerness of industry to find out about this new source of energy and just what is needed to make an atomic power station. Speaking at the opening ceremony Sir Christopher Hinton, the chairman of the new Electricity Generating Board, said he thought it most improbable that the members of the present atomic Big Five would be able to fabricate and erect all the plant required under the programme; they would find it more and more necessary to buy specialized, and even general, engineering items from firms best able to supply them at the most favourable price. He emphasized the fact that much of the plant needed would be conventional because the equipment in the actual turbine hall of an atomic power station differed in no way from that of a conventional station. Nevertheless, Sir Christopher stressed that even in this field there must be a never-ending effort to make these items even more efficient, more profitable and more reliable than ever.

Outside the turbine hall things are very different. Here the equipment required is specialized to a greater or less degree. In some cases, such as the reactor itself, the components have no counterpart in normal engineering: in others, such as the boilers and pumps, the parts have resemblances to conventional plant but have to be modified—sometimes drastically—to meet the special needs of nuclear power. On the control and instrumentation system, a large part is quite specialized while much of it is 'normal'.

Whatever the plant or equipment to be supplied however, whether special or normal, it must be designed and made to the most rigid specifications of performance, safety and reliability. This is a challenge to British industry which must be, and is being, met. Here, the two Authorities, Atomic Energy and Central Electricity, have played an invaluable educational function. At the same time, it cannot be emphasized too strongly that simply waiting for one of the authorities or the contracting groups to make an approach is not the way to do atomic energy business. As Sir Christopher said, firms ought to acquire sufficient knowledge of nuclear power technology to enable them intelligently to meet the requirements of the consortia or other organizations. In other words, they must learn to anticipate what will be needed and have it ready when the call comes. This needs money for development but in the long run it will be money well spent.

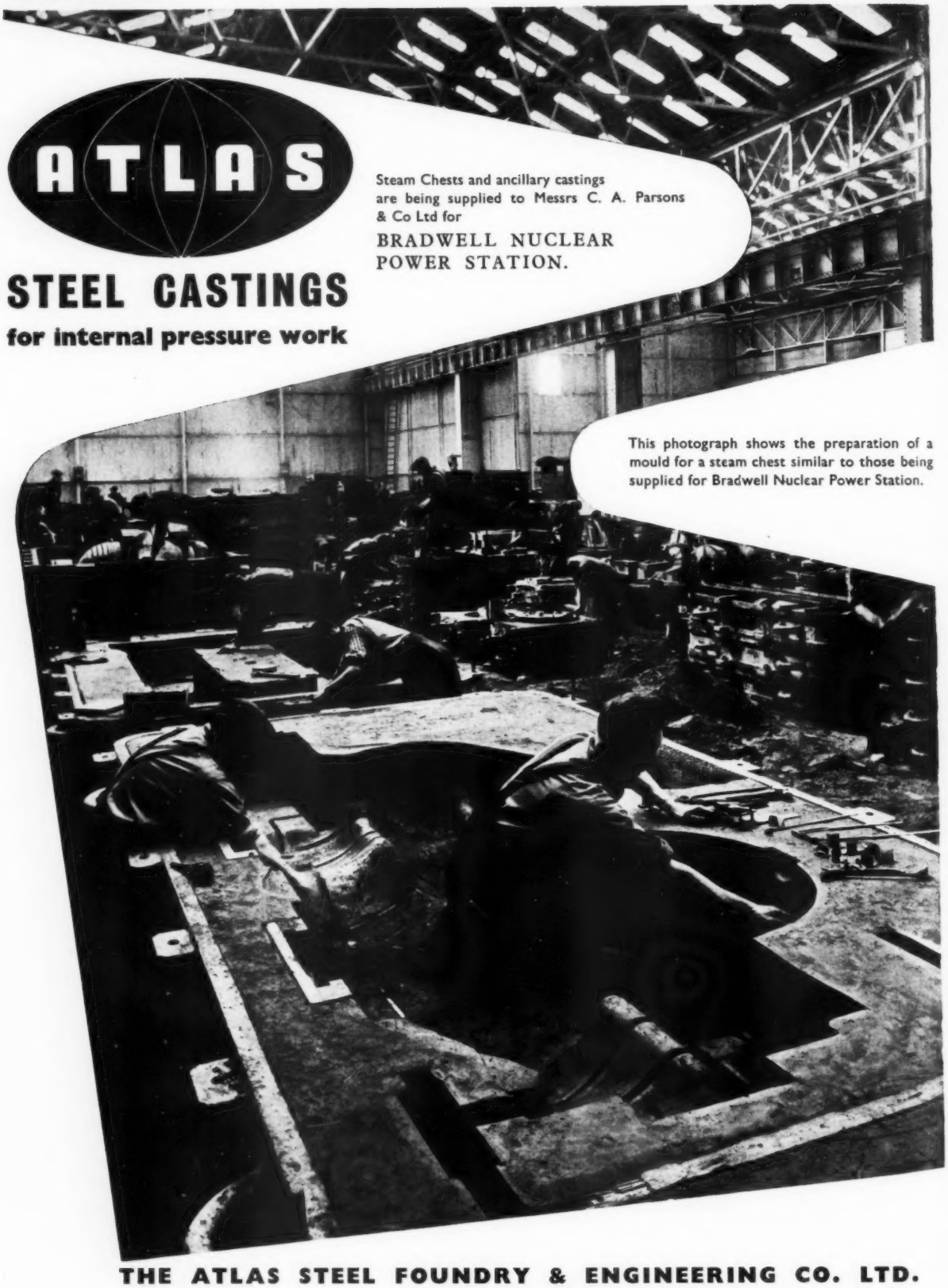
This issue of NUCLEAR POWER is devoted almost entirely to just one power station and gives an outline of most of the multifarious activities that go into it. If it interests just one manufacturer sufficiently to develop or adapt a plant item, an instrument or a component for atomic power then it will have served its purpose.

ATLAS

Steam Chests and ancillary castings are being supplied to Messrs C. A. Parsons & Co Ltd for
BRADWELL NUCLEAR POWER STATION.

STEEL CASTINGS

for internal pressure work



This photograph shows the preparation of a mould for a steam chest similar to those being supplied for Bradwell Nuclear Power Station.

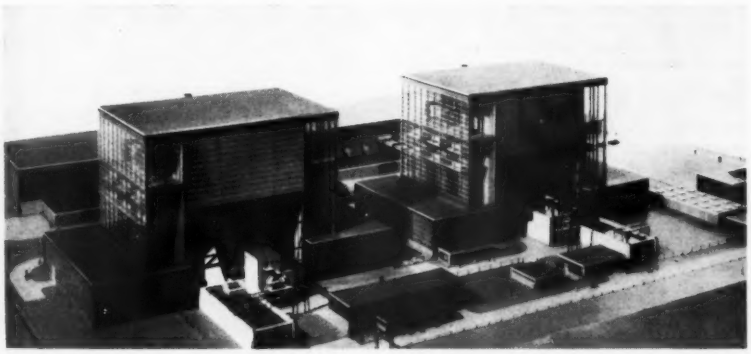
THE ATLAS STEEL FOUNDRY & ENGINEERING CO. LTD.

Atlas Steel Works, Armadale, West Lothian, Scotland

Telegrams: "Atlas, Armadale, West Lothian" *Telephone:* Armadale 323.

Hinkley contract awarded

With a net output of 500 MW electrical, Britain's latest nuclear power station at Hinkley Point, Somerset, is by far the largest yet projected anywhere in the world. News of the successful bid by the English Electric group was announced in London on September 13, subject to the satisfactory conclusion of certain details. Speaking in London later, EE managing director H. G. Nelson said the total cost of the plant would be about £M60 and would thus be one of the biggest orders ever placed with a British firm. First round stations had a capital cost in the range £130-140 per kW: Hinkley Point would bring this down to £110. Generating costs, he believed, would be below 0·65 pence per unit—the national average at present. Mr Nelson emphasized the team nature of the project and introduced Mr Frank Taylor of Taylor Woodrow Ltd and Mr Hector McNeil, deputy managing director of Babcock and Wilcox Ltd, the two companies associated with English Electric in nuclear power station construction. Mr Nelson said the joint design group had a staff of 300 highly trained men working on these projects and although the companies included in the English Electric group represented a very powerful combination, it did not exclude smaller firms: in fact, very many subcontractors would be needed for the Hinkley Point contract and this would give employment to thousands. The group's chief engineer, Henry Shull Arms gave some technical details of the station.



Britain's biggest nuclear power station so far, Hinkley Point, will be built by the English Electric: Babcock & Wilcox: Taylor Woodrow Group for the Central Electricity Authority. Model of the station shows its two reactors which will deliver 500 net megawatts to the Grid. Work has already started at the site on the North Somerset coast

Spherical shells

Like all the British stations so far, Hinkley Point will be natural uranium, gas-cooled, graphite-moderated. The two reactors will be in 67 ft 3 in. diameter, 3-in. thick spherical pressure vessels in 28-ton steel. Designed for a gas working pressure of about 12 atmospheres (180 psi), the shell will be supported on a steel skirt supported on bedrock. The graphite pile will be a 24-sided prism about 50 ft dia. and 30 ft high, supported on an egg-box grid inside the sphere. Fuel is loaded and unloaded from the top through standpipes and there will be eight elements to the channel, separately supported and with an anti-buckling support. The canning material will be *Magnox* and the finning will be coarse pitch helical. Total fuel per reactor will be in the range 300-400 tons.

Steam generation will take place in six dual-pressure boilers ranged three each side of each reactor. Built by Babcock and Wilcox, these heat exchangers will each raise about 500,000 pounds of steam an hour and will be connected to the sphere by ducts mostly of 6 ft diameter, although this is not constant throughout the circuit. Extended surface to the boiler tubing will be by welded studs—an improved version of the Babcock system used at Calder Hall. About two thirds of the total steam flow will be high pressure—650 psi, 700°F. Axial-flow blowers with horizontal shafts will be fitted directly below each boiler and they will be driven by variable frequency motors supplied from variable speed turboalternators situated in the main turbine hall.

On-load fuelling

Control of the reactors will be by varying the speed of the blowers so as to keep the upper temperatures nearly constant.

Biological shielding is in the form of a dodecagonal wall about 7 ft thick round the sides with the conventional pile cap on top. Fuelling will be on-load and it has been decided to use two machines for this: one to prepare the hole and insert the charge chute, and the other solely for fuel elements.

The turbine hall contains six main 93·5 MW sets together with three 33 MW variable speed sets for the blower drives. The l.p. ends are two-cylinder double exhaust, very similar to the ones used in the 200 MW English Electric sets at the CEA's new High Marnham coal-fired station.

How output was increased

Asked why Hinkley Point would have such a high output compared with similar first round stations—500 MW compared with Bradwell's 300 MW—with a pressure shell almost exactly the same size and thickness, H. S. Arms said this was done by nothing very radical but by a lot of detailed changes, the effects of which multiplied—not added. For example, he said that by a rethink on the fuelling system it had been found possible to shorten the charge chute by about a foot. This meant that the core could be that much higher: thus about 5 pct more fuel could be contained, with about the same increase in output. It was by getting 5 pct here and 10 pct there that the output had been raised to its present figure. Mr Arms thought that even now we were nowhere near the limit and further increases could be made in future stations.

Comparison of Hinkley Point with the EE group's first tender shows a complete reversal of architectural planning. Instead of the boilers in the open air, they are now in glazed enclosures similar to those used in the other British stations at Bradwell, Berkeley and Hunterston. This could be taken to indicate a CEA preference for enclosure for maintenance and amenity reasons.

Site work has already started and a wharf is being built at Combwich, six miles away, to handle seaborne components.

More firms needed—Hinton

It will be 'quite impossible' for the firms constituting the five existing consortia to expect to fabricate and erect all the plant needed for nuclear power stations, especially as a large proportion of stations built in this country for the electricity authorities will be nuclear by 1965. This opinion was voiced by Sir Christopher Hinton in opening the Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia. While these consortia may remain responsible for the design and construction of many nuclear stations, they will, said Sir Christopher, 'find it more and more necessary to buy items of plant from those specialist and general engineering

firms which are best able to supply suitable equipment at the most favourable price.' Much of this plant would be conventional in character because the turbines, condensers, pipework and switchgear in a nuclear power station differ 'in no way' from similar plants in a conventional station. But many components —heat exchangers and control gear—are entirely specialized and it would seem that firms hoping to tender for them ought to acquire sufficient knowledge of nuclear power technology to enable them to meet the requirements of the consortia intelligently. It was partly to meet this requirement that the training schools at Harwell and Calder existed.

In the export field too, Sir Christopher thought the consortia would find overseas countries interested in nuclear energy unwilling to import components they are capable of manufacturing themselves. 'In these markets I should have thought that they would be well advised to sell design and construction knowhow through the medium of licensing arrangements.' But all of this depended on our ability to design plant which is more efficient, more profitable and more reliable than those designed by our competitors, and to do this our engineers must be well trained.

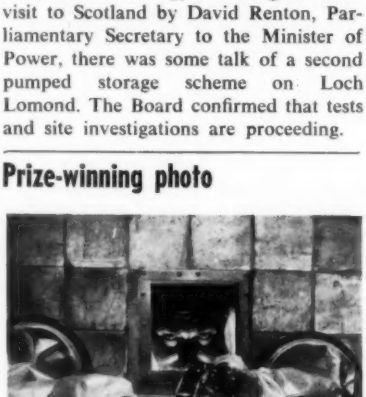
Fairey and Elliotts to join APC

According to unconfirmed reports in London last month, the Fairey Aviation Co Ltd and Elliott Brothers (London) Ltd are to join Atomic Power Constructions Ltd. At the moment, the APC group comprises Richardsons Westgarth, International Combustion, Crompton Parkinson, and Nuclear Civil Constructors. The agreement is understood to involve setting up main research and development headquarters at Fairey's Heston factory. Computer facilities for the group will be provided by Elliotts at their Boreham Wood laboratories. This move would make APC the only one of the big five to be associated with an aircraft manufacturer, and the group is believed to have appointed a team of experts for development of reactors for aircraft and marine propulsion.

Nuclear station for N. Scotland?

The expanded British nuclear programme leaves room for a second station in Scotland, according to a statement made recently by Lord Strathclyde, Minister of State, Scottish Office. The North of Scotland Hydroelectricity Board has been seeking a site for some months, and test borings have been made in the Crimond area of Aberdeenshire. No decision has yet been made. In view of Hunterston and also the SSEB's new station, Kincardine-on-Forth, which may ultimately have a rated capacity of 760MW, the hydroelectric board has proposed a 450MW pumped storage scheme, based on Loch Awe, Argyll. During a recent visit to Scotland by David Renton, Parliamentary Secretary to the Minister of Power, there was some talk of a second pumped storage scheme on Loch Lomond. The Board confirmed that tests and site investigations are proceeding.

Prize-winning photo



Chief UKAEA press photographer J. H. Jochimsen, won the Merit Award for the year's most outstanding picture in the commercial section of the Institute of British Photographers' annual exhibition held in London last month. Known in AEA circles as the Amersham horror picture, the photograph has been published widely in this country and overseas.

New Risley director appointed

Following Sir Christopher Hinton's appointment as chairman of the CEA Generating Board (*Worldview*, September), his place as managing director of the Industrial Group of the UKAEA has been taken by Sir Leonard Owen, CBE, formerly Sir Christopher's deputy. Created knight in January, 1957, Sir Leonard, who is 60, has been engaged in Britain's nuclear programme since 1946, when he was appointed director of engineering on the production side by the Ministry of Supply.

In the following year, he became assistant controller in the Atomic Energy Division's production side. When the UKAEA was formed in 1954, his title became director of engineering and deputy managing director.

Nuclear plane needs 15 years

At least 15 years would be needed for Britain to develop a prototype nuclear-powered aeroplane, is the view of Dr J. V. Dunworth, head of the reactor division at Harwell, speaking to the sixth Anglo-American Aeronautical Conference in Folkestone last month. In terms of money and manpower it would be very expensive—he estimated that initial construction cost of a land-based experimental reactor would be in the region of £M5, excluding site costs. Cost of a full-size system might well exceed £M10. A development programme would involve the construction of a number of zero energy experiments which would cost around £200,000 and the actual cost of fuel might be higher. A high-flux materials testing reactor would cost about £M5, and would involve heavy annual expenditure for staff and equipment.

Fuel in an aircraft reactor, probably highly enriched uranium 235, would have a life approaching 100 days' operation at full power and further fuel would be needed for reprocessing plants. Fuel costs for a single aircraft reactor would be in the order of £M1 upwards, varying with size and type of reactor. Dr Dunworth had little doubt that a nuclear aircraft would be built, but believed that nuclear marine propulsion had a more immediate future.

ZETA up to full power

The zero energy thermonuclear apparatus put into operation at Harwell on August 15 (*Worldview*, August), has been run up to full power. First results are reasonably encouraging but some time will be needed for their interpretation. This was stated by J. D. Lawson, Senior Principal Physicist at Harwell, speaking last month to the physics section of the British Association in Dublin. Little new information on the project was revealed, but the discussion following the session conveyed the difficulties involved. In a paper on *Containment problem for thermonuclear reaction*, Sir George Thomson suggested that a kinked tube could be used instead of a toroid or straight tube. As power from a fusion reaction would be extracted from the magnetic field of the plasma, which is at right angles to the driving field, it would be an advantage to turn the plasma through 90° so that the energy could be extracted by the circuits setting up the containing field. As a possible intermediary step in using thermonuclear power, Lawson suggested that a fusion system could be incorporated in a fission reactor, using the thermonuclear neutrons to breed fissionable material.

A last-minute session on the recent manufacture in Sweden of element 102 by a team of Swedish, American and British scientists (*Worldview*, August) was introduced into the programme. A paper was presented to the chemistry section by Dr J. Milsted, one of the British members of the team, and H. A. McKay, head of Harwell's chemistry division.

President-elect of the BA for 1957-8 is Sir Alexander Fleck, KBE, DSc, FRS, chairman of ICI since 1953. Born in Glasgow in 1889, he joined ICI in 1920, joining the main board in 1944.

50 MW station for export

Design of a small, graphite-moderated reactor, fuelled by enriched uranium,

suitable for a 50-100MW power station, is a major project in the GEC research programme. This is stated in a booklet called *GEC Atomic Power Achievements*, recently circulated to shareholders. A reactor of this size is considered to have considerable export possibilities, and it is estimated that the cost would be competitive with diesel generators. Possible usefulness of beryllium is being investigated in collaboration with the UKAEA. Ceramic fuel elements for withstanding higher temperatures are also being considered, and also, looking further into the future, the use of organic liquids for cooling, or cooling and moderating.

CEA-EdF link-up plan

Formal approval in principle has been given by the Minister of Power to the proposal for a high voltage interconnexion between the CEA and Electricité de France supply systems. Principal items of the connexion as now planned will include a 275 kV overhead line between a substation at Canterbury and a terminal near Dungeness, a converter station at this point to change the 275 kV alternating current to 200 kV direct current, a single submarine cable between the Dungeness terminal and a converter station to be built east of Boulogne. Here the d.c. will be converted back to 225 kV a.c. and a connexion made to the French system. The d.c. connexion has been chosen because it gives better power transfer control and is virtually independent of the frequencies of the two systems. The 35-mile submarine cable will have a nominal transmission capacity of 160 MW in either direction. Half will be made in each country. Total cost of the scheme to the two countries will be of the order of £M4, excluding extensions to be made to the systems to join up with the interconnector.

INTERNATIONAL

UN agency meets

Meeting in Vienna from October 1 is the first general conference of the International Atomic Energy Agency. The first session, expected to last about a week, will be concerned with setting up the agency, electing officers and the ten members of the 23-strong board of governors which have still to be selected. After this, a special session will be held to discuss the report of the preparatory commission (*Worldview*, September), the scale of contributions of members, location of the Agency headquarters, and appointment of the Director-General. Strong candidate for this post is W. Sterling Cole, member of the US House of Representatives. He has served on the Joint Congressional Committee on Atomic Energy since its formation in 1946 and was chairman in 1953 and 1954. As a member of the US delegation, he took part in drafting the IAEA statute in October 1956.

Nuclear courses in Europe

Designed for students and young engineers who wish to further their knowledge of nuclear energy, a recently published catalogue by the OEEC gives an overall picture of study facilities available in Europe during 1957-58. It contains a list of universities and technical colleges providing courses, with names of lecturers, and diplomas which may be obtained, and level of instruction given, together with information about research establishments providing instruction and training. To be brought up to date each year, the catalogue is available from the OEEC in Paris.

DENMARK

Water boiler on stream

A homogeneous research reactor designed and built for the Danish AEC research establishment at Risö by Atomics International Inc. went into operation at the end of August. Designed to operate at a power level of 5 watts, it has provisions for increasing power for special research. Fuel is uranyl sulphate enriched in uranium 235, and reactor design ensures that all radioactive fission products are retained in the unit. The core and other reactor components were built by Atomics International in Los Angeles earlier this year and installation and start-up of the reactor was achieved under the supervision of company representatives on site. It will be used for training and research, and for the production of isotopes.

FRANCE

Uranium prices will fall —Cockcroft

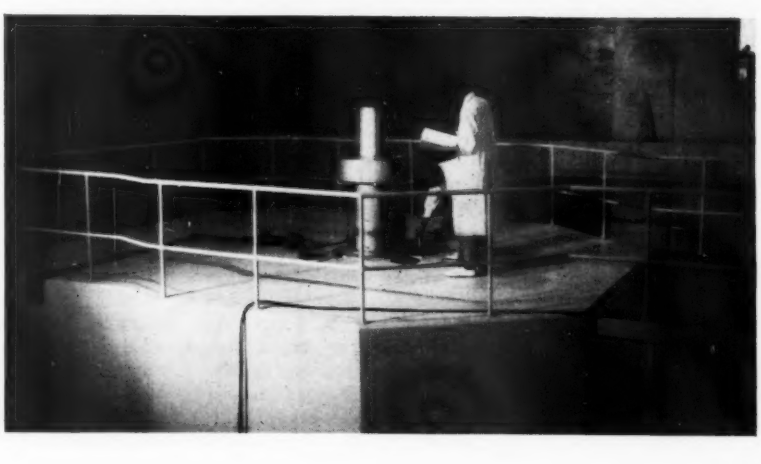
Recycling of plutonium will be well established by 1965-70 and thorium may be included as fertile material. This is likely to have better nuclear characteristics for thermal reactors than uranium. Sir John Cockcroft predicted this in Paris last month at an international conference on radioisotopes arranged by UNESCO. He added that experience of radiation damage of plutonium enriched fuels in some carriers had been very favourable. The conference was the biggest exchange of nuclear information since Geneva and the papers dealt only with developments since 1955. At that time, Jesse Johnson foresaw that the price of uranium oxide would fall towards 10 dollars a pound by 1965. Since then many more uranium deposits had been found, especially in Canada, and Sir John believed that prices are likely to fall even lower than this. Supplies of well over 30,000 tons of oxide a year seem assured. If the Euratom plan is fully implemented, the annual burn-up of European and UK nuclear power stations in 1975 might require 5000 tons of uranium a year if plutonium recycling is then in full swing. Another 5000 tons would provide the initial fuel charge for about 5000 MW of new installations per year. These requirements would of course be reduced by improvements in neutron economy or by the successful introduction of breeder reactors.

SOUTH AFRICA

Union to get enriched U

An agreement is reported between South Africa and the US under which the Union, as a leading producer of low grade uranium, will have access to stocks of enriched metal. It is estimated that South Africa has enough uranium oxide to sustain likely production for 61 years compared with 16 in the case of Canadian output and 10 years in the Ameri-

JAPAN'S FIRST REACTOR
The ' water-boiler ' or solution-type reactor built at Tokai-Mura for the Japanese AEC by Atomics International went into operation last month. Built for research purposes, it will produce 50kW thermal; director is Dr Toyozo Kambara



can case. Exports of 'prescribed materials' during the first half of 1957 were officially valued at £M22·7 compared with £M16·5 in the same period last year.

SWITZERLAND

Isotope importance emphasized

The only field in which atomic energy can be of any use at all in the less developed countries for many years to come is the utilization of isotopes in agriculture and public health, Ichiro Kawasaki, Japanese government observer, recently told the 24th session of the United Nations Economic and Social Council in Geneva. This is because these countries are predominantly agricultural, and because their populations are subject to numerous diseases, many of them epidemic. At the time of the Geneva conference, atomic energy was believed to be a panacea for economic development and, accordingly, great hopes and expectations had been entertained. Since then, however, experience had shown that in the less developed countries, various economic conditions make it extremely difficult for atomic energy to contribute immediately to their economic betterment. Many of these under-developed countries had a low productivity of labour and a low national income. Furthermore, they lacked capital and scientific technology. Thus it was virtually impossible for them to accelerate their industrialization through development of nuclear power.

Notwithstanding the slowly increasing assistance from the advanced countries in this field, such as export of small research reactors, the underdeveloped countries are lagging far behind the industrialized nations which are now engaged in such ambitious schemes as Euratom. The greatest difficulty at present for the less developed countries, in both the use of isotopes and nuclear power as a source of energy, was the shortage of technicians and scientists. It was of particular necessity that technical aid in this specific field should be made available by advanced countries and international agencies.

UNITED STATES

New type particle accelerator

A 30MeV travelling wave accelerator is to be installed within a year by General Atomic at its John Jay Hopkins Laboratory for Pure and Applied Science. Said to be a new development in particle accelerators, it is based on microwave research done during and since World War II. It will have two 6 ft wave guides energized by a klystron, each delivering 5 MW peak power. Electrons will be injected into the system by a high voltage electron gun pulsed simultaneously with the power tubes. At peak power, electron speed will be over 99 pct that of light. As the beam intensity is high, wave guide sections will be water-cooled. Energy range of the machine will be from 2 to over 30 MeV and it will deliver between 1000 and 5000 watts to the electron beam.

General Electric BWR by 1958

Facilities to house the General Electric materials testing reactor to be built at its Vallecitos Atomic Laboratory will be designed and constructed by the Ralph M. Parsons Company of Los Angeles. Completion of the facilities is scheduled for summer, 1958, and criticality for later in the year. It is a boiling water reactor fuelled with fully enriched uranium with a cylindrical steel containment vessel, 66ft dia and 104ft high. It is one of the first large test reactors to be financed and built by private industry; estimated cost is $M4.

Nuclear glossary published

A glossary of terms in nuclear science and technology has been approved as an American standard and will be published by ASME. Containing nearly 200 pages, the book is designed to provide a common language for engineers, chemists, physicists, biologists and medical workers. Three categories of terms are included: those invented expressly for the nuclear field, those borrowed from other fields and given different meanings, and those used elsewhere but possibly unfamiliar to nuclear workers. Definitions, tables, charts and formulae which are considered useful are included. Preliminary drafts of the glossary were requested for use at the 1955 Geneva Conference and the 1957 nuclear congress in Philadelphia. The British Standards Institution is using this as a basis for its own dictionary. Copies are obtainable from the ASME, 29 West 39th Street, New York, NY.

AtomFair opens soon

Displays from more than 120 organizations will be involved at the annual trade fair of the atomic industry to be held at the New York Coliseum from October 28 to 31. This will be in conjunction with Atomic Industrial Forum's annual atomic industry conference. AtomFair '57 is designed to give business and technical management an opportunity to see at first hand the latest developments in atomic energy research and application.

Dr Henry Smyth, author of the famous Smyth Report, will be luncheon speaker at the American Nuclear Society's second winter meeting on October 29.

WORLDBRIEFS

Argonne National Laboratory awarded design contract to United Engineers and Constructors Inc, Philadelphia, for $M8·5 boiling water reactor. Known as ARBOR it will investigate full-scale power systems. Contract for erection of reactor at Idaho site should be placed next July.

Idaho Operations Office of US Atomic Energy Commission placed $M6 contract with three companies for Flight Engine Test Facilities. To be built at the NRTS, Idaho, facility will enable aircraft propulsion units to be tested in conjunction with airframes, crew compartments and aircraft control systems. Construction to start immediately: completion in 2 years.

AMF Atomics, New York, are to supply 1MW pool reactors to: Hamilton College, Ontario; Greek AEC, Democritus Nuclear Centre; Junta de Energia Nuclear Lisbon.

Designs for a 40MWe natural-uranium graphite-moderated, gas-cooled reactor have been invited by the United States AEC. The Commission will report on tenders to the Joint Committee next April.

Swordfish, fourth American nuclear submarine, was launched at Portsmouth, New Hampshire, last month. Fifth sub—**Sargo**—goes down the ways from Mare Island Navy Yard, Vallego, California, on October 10.

Japanese cabinet are to establish company to import and operate reactors. Government will own 20 pct capital and retail final control; private enterprise will own 80 pct.

Maps showing areas in Southern Rhodesia where strong radioactivity has been located are on sale at the UKAEA Salisbury office.

India will be able to set up its first nuclear power station in five years' time, says Dr Homi J. Bhabha, AEC chairman.

Small scale reactor, which can be operated by one man, has been designed by Atomics International for use in schools and laboratories. Contained in a 8ft by 8ft cylinder, fuelled with uranyl sulphate, it will cost about £20,000.

Nautilus will be one of 29 ships of US Navy visiting Portland Harbour for the NATO exercises from September 30 to October 10.

South African Secretary for Mines and deputy chairman of Atomic Energy Board, Mr V. H. Osborn, recently travelled to US and Britain for talks and visits to nuclear plants.

1,000,000 kW will be installed capacity of new CEA conventional power station to be built at West Thurrock, Essex, planned for commission in 1961.

A message to NUCLEAR POWER from the chairman of the company that is building Bradwell power station
Sir Claude D. Gibb, KBE, FRS
The Nuclear Power Plant Co Ltd

BRITAIN LEADS THE WORLD

in Atomic Power Development

FROM HIROSHIMA to Bradwell in a mere twelve years. What a magnificent period of achievement.

British Industry so frequently is accused of slowness in adopting new ideas and new techniques, but 'The Bradwell Story' gives the lie direct to such accusations in a manner beyond dispute.

The United States claims the credit for having developed the first atomic bombs, but it is now well known that in that development British scientists and scientists of other nations contributed greatly and that without that help there could have been no bomb on Hiroshima, which was to bring to an end abruptly the war in Japan.

With the cessation of hostilities in 1945, there was a sudden and quite inequitable clamping down on all atomic information which had been accumulated in the United States and to which so many non-US nationals had contributed, with the result that Great Britain had to start almost from scratch.

Establishing a base

The creation of the Atomic Energy Research Establishment at Harwell was the first step, and no tribute great enough can be paid to Sir John Cockcroft and his staff for the magnificent work they have done, and are doing, at Harwell. Initially, their problem was to establish the fundamentals of nuclear physics and to accumulate data which had been available in USA and which now had to be re-established as a firm basic for British developments. This they did in an extraordinarily short time.

Next came the creation at Risley of the Engineering Division (now called the Industrial Group of the UKAEA) and, as always in British history in times of crisis, one man has risen above his fellows and become the Man of the Hour. It is no exaggeration to say that just as Winston Churchill became the Man of the Hour in 1940, so also did Christopher Hinton become the Man of the Hour in the creation of Risley. Hinton took with him to Risley his life-long friend and colleague, Leonard Owen, and between them they attracted around themselves a group of engineers and scientists who, in enthusiasm, ability and effectiveness the like has probably never been seen before anywhere in the world.

Widely different talents

The task of Risley was to apply the fundamental knowledge gained at Harwell, and the trio of Cockcroft, Hinton and Owen—by temperament and nature so widely different from each other—has given Britain a world lead which is exemplified by Bradwell and the other nuclear power stations now building or about to be built in Britain. As a friend of many years of this trio, it has been fascinating to be associated with them and to observe the way in which those three widely different men achieved so much with relatively so little upon which to work. Cockcroft, the true research worker, seeking nothing but to widen fundamental knowledge and having no great interest in the concrete, steelwork and ironmongery which Hinton and Owen had to create out of that fundamental knowledge. Hinton, the brilliant engineer so thoroughly trained in the fundamentals of Applied Science, possessing an impatience, a 'fire in the belly,' an almost visionary's picture of what was and what was not possible engineering-wise, who drove himself and his staff at a pace that almost brought about his own breakdown and might well have brought about the breakdown of many of his staff had it not been for the 'cushion' that existed in W. L. Owen. W. L., as he is affectionately called, never gets disturbed—never loses his temper—conveys an impression of placidness that is entirely false, because he can be, and often is, completely ruthless—cushioned the fire of Hinton and yet never allowed any deviation from rigid and tight programmes of timing for the execution of the many brilliant engineering designs and structures which have been accomplished in Britain in the nuclear field.

It will probably be many years before the nation as a whole recognizes the great achievements of those three men in the nuclear field. All three have received honours and all three have been knighted as some token of recognition by the nation. But it will be in industrial history that they receive full recognition.

The role of Industry

Britain, once a great exporter of coal, has now to import special coals, and the once important British asset of coal to spare can be and is being replaced by the industrial application of the pioneering work of what is now the United Kingdom Atomic Energy Authority.

The UKAEA provided training facilities for British Industry, and Industry was not slow in seizing the opportunities provided. That training has been given a firm footing by experience in the construction and operation of the now world-famous Calder Hall. So successful has been Calder Hall that it is the envy of the world. Some nations are so envious that they damn it with faint praise. It has been called the 'Model T,' but of course it was the Model T Ford which shook the very foundations of the automobile world and made possible motoring for those with only a limited depth of pocket.

It is always much easier in engineering to design the second and third of a revolutionary new engineering project once somebody else has faced and solved the problems of designing and building the first one. And British Indus-

try has had an incalculable advantage in designing their nuclear power stations after having had access to all the brilliant thinking that went into the creation of Calder Hall.

Bradwell is a great advance on Calder Hall, and so it should be. The nuclear power stations to follow Bradwell will be great advances upon Bradwell, and as each successive station is built and its operating experiences incorporated into new designs, so will nuclear power stations take their place as a substitute for coal or imported oil and make a major contribution to improving living standards in Britain.

Importance of coordination

Whilst the need for Britain to develop industrial nuclear power is greater than probably any other nation in the world, yet there are many other countries where their traditional fuels or sources of power are not keeping pace with their growing demand for electricity, and those countries will look to Britain for help in increasing their own electricity supplies. The ability of British industry to meet that coming demand will be limited very largely by the availability of technical staff of the calibre essential to deal with such a complex project as a complete nuclear power station.

From a long and quite wide engineering experience, I can say with absolute certainty that there is no major engineering project known to man which calls for such close coordination of so many branches of science and engineering as does a nuclear power station. Only by having specialist scientists, engineers, metallurgists, working together as a team and under one roof will it be possible to design and construct nuclear power stations with the efficiency, speed and effectiveness which is essential if Britain is to maintain the world lead it now enjoys. Such experienced technical staff as is available to industry must be concentrated into the minimum number of teams which can cope with our home and overseas nuclear programme. To disperse our effort is to court certain failure. The fact that your technical staffs are concentrated into a small number of groups by no means means that productive capacity similarly is concentrated. In the building of Bradwell Nuclear Power Station, something like 1000 firms will contribute. The spread of manufacturing capacity in a nuclear power station is at least as wide as and probably much wider than is the case with a coal or oil-fired power station.

A proud achievement

Britain is leading the world, and, with courageous acceptance of that position in Government circles, British industry is ready and in fact eager to maintain that lead and even increase it. British scientists and engineers have demonstrated by their work in the nuclear field that they do not lag behind any nation of the world. That is an indisputable fact and one of which all may be proud.

Engineers, so frequently having achieved something worthy of being told to the world, become so immersed in problems arising out of their initial achievement that they have neither the time nor the desire to shout from the house tops. Our friends across the water have no such inhibitions and, as a result, sometimes receive credit to which they are not truly entitled. This issue of NUCLEAR POWER it is hoped will at least do something to dispel that misconception.

Leading personalities on the Bradwell project

Arthur J. Sayers, AMIEE, Director and General Manager, NPPC Ltd

Born in 1901, Joe Sayers served an apprenticeship with the old Midland Railway and in 1920 went to the Yorkshire Electricity Power Co for power station and overhead transmission work. In 1926 he joined Preece, Cardew and Rider, the consulting engineers, and was involved in power station work at home and overseas. Returning to industry in 1936, Sayers joined Parolle Electrical Plant Co and became a director and general manager. During 1948-1955 he worked on the Calder Hall project and became general manager of the Nuclear Power Plant Co when it was formed in 1955.

R. D. Vaughan, BMechE, AMIMechE, Chief Engineer, NPPC Ltd

Australian-born Roger Davison Vaughan leads the NPPC design group at Booths Hall, Knutsford, which carried out the design of the nuclear power station now under construction at Bradwell. Vaughan acquired his basic knowledge of nuclear work during a year at AERE, Harwell. Before this he was for three years in Calcutta as Chief Engineer for C. A. Parsons & Co Ltd. His early experience also included the design of plant for manufacture of antibiotics.

A. Young, MIMechE, Chief Resident Engineer, NPPC Ltd

Andrew Young joined the Nuclear Power Plant Company Limited in January 1957 as Chief Resident Engineer, Bradwell. Prior to this appointment, Young held a similar position at Calder Hall. His association with plant construction for nuclear projects began in 1947 at Windscale as engineer in charge of plant installations. This was followed by a period at Aldermaston. During the war years, Andrew Young was concerned with the construction of ordnance factories; he was also a deputy director with the Ministry of Aircraft Production (light alloy industry expansion). Between the wars, Young served in Malaya and Dutch East Borneo as a senior mining engineer.

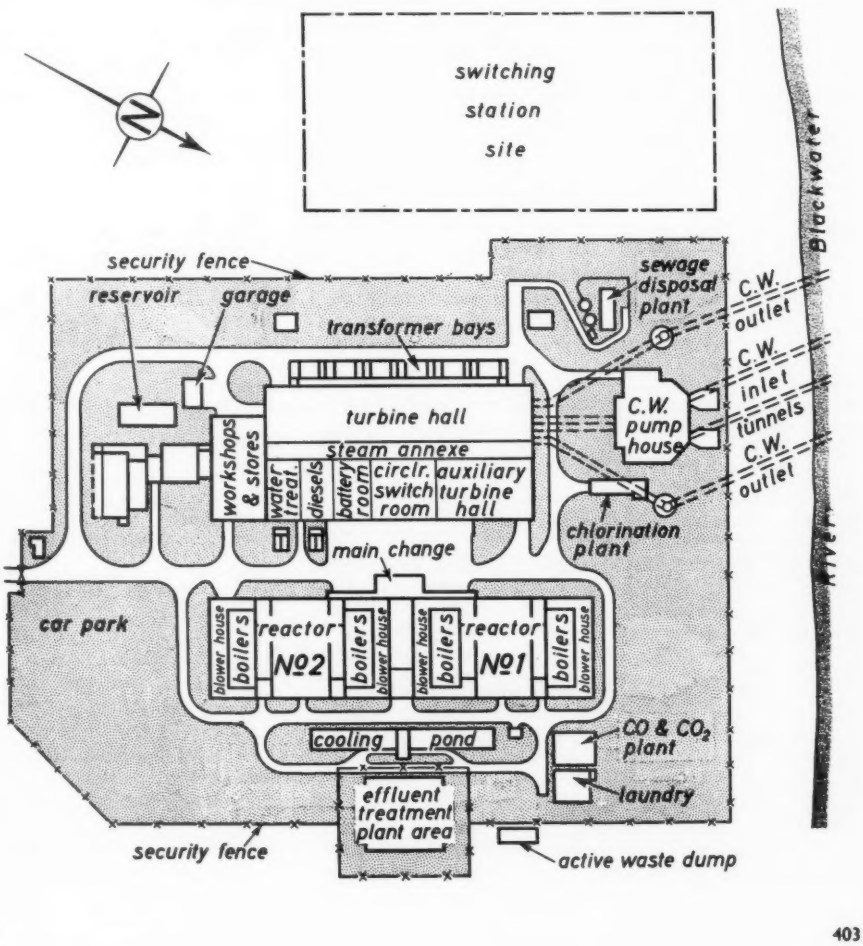
CIVIL ENGINEERING AT BRADWELL

A. HOUGHTON BROWN BSc (Eng), MICE
Chief Civil Engineer, The Nuclear Power Plant Co Ltd

THE CENTRAL ELECTRICITY AUTHORITY launched their construction programme for nuclear power stations by the issue of an invitation to tender for both the Bradwell and the Berkeley stations to each of four groups of contractors. The Authority used a form of invitation which had no precedent in the methods they had used for placing contracts for orthodox stations in that the groups were required to submit a lump sum tender for complete stations to their own designs.

The preparation of a tender on a lump sum basis is not unusual for a plant contractor, although it may contain alternatives for later selection. In the case of the civil contractor however, works of the magnitude required are usually dealt with in this country by measure-for-value contracts, unless the works are so ill-defined or intricate that a cost-plus basis is adopted for convenience. This lump sum method of tendering, therefore, imposed unusual responsibilities and difficulties on the civil contractor and these were not only associated with a contract several times greater than any single contract let by the Authority for civil engineering and building works, but also two designs and tenders were to be prepared concurrently.

Sir Robert McAlpine & Sons Ltd, as a member of the Nuclear Power Plant Co Ltd, undertook the responsibility for the design and construction of all CE and building works and to carry out the former function assembled a team largely by special recruitment. This team is stationed at Booths Hall, Knutsford, alongside the design teams engaged on plant for the NPPC and other member firms, thereby providing ready means for the closest day by day consultation and cooperation. The architecture was carried out by Mr Maurice H. J. Bebb and structural steelwork



The power station site is located on the south shore of the Blackwater estuary in Essex and is largely below high-tide level, protected by an earth-fill, concrete-faced river wall. A requirement however was that all buildings and roads should be safe even if the wall were breached and they will all be raised above flood level. Circulating water for the turbine condensers will be brought through tunnels from intake works in the estuary

was designed by Alexander Findlay & Co Ltd, who are to supply and erect.

The invitation to tender was issued by the CEA in October 1955, the sites were designated towards the end of that month and the tenders were lodged on October 1, 1956. In this period the whole of the CE and building works for the two stations was designed, drawn and priced, but a real start on the design on firm lines could not be made for the first several months while the plant design was under development. To reduce the work involved, the design for all works above ground level was kept similar for the two stations but particular designs were obviously required for each station for foundations, circulating water works, roads, drains, etc.

Survey and soil investigation

The CEA decided it was unacceptable to permit representatives of each of the four groups to carry out topographic and hydrographic surveys and soil investigation on the same sites at the same time. The Authority, therefore, arranged for this work to be done by specialists under the supervision of consulting engineers and reported the results to the groups tendering. A working party was set up with representatives of all interested parties to receive information and decide on further requirements.

Since the letting of the contract for the Bradwell station to the NPPC, further soil investigations have been carried out and are being continued from time to time as necessary, such as additional borings, trial pits and tests on samples.

The site generally is on London blue clay, extending down at least 150 ft, and overlain by brown weathered clay with a small depth of soil at the surface. The shear value of the clay increases with depth and foundations have been designed appropriately with bearing values related to depth. Estimates were made of elastic movement on removal of overburden and these have been approximately confirmed during construction of rafts by level values taken on tell-tales inserted at levels below formation before commencement of excavation. There appeared also to be risk of heave from water penetration as the reports of the boreholes stated the clay was fissured. This effect has not been discerned as precautions were taken against it during excavation, assisted by very favourably dry weather.

The CEA informed the Nuclear Power Plant Co on December 13, 1956, of their intention to place with them the contract for the Bradwell station. This allowed attention to be concentrated on the one station, detailed development of the design to be continued and preparation made for a start on site when made available.

Layout of station

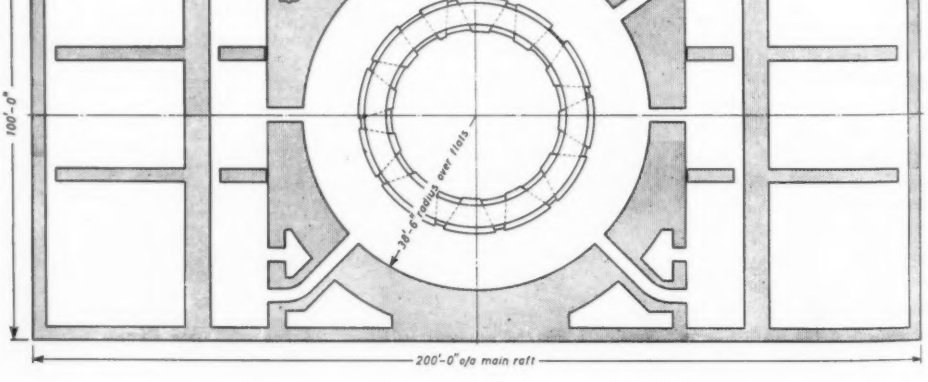
The site of the station alongside the Blackwater estuary is for a large part below the high-tide level and is protected by a river wall built of earth with concrete protective facing on the seaward side. It is a requirement of the design that all buildings shall be protected from flooding, in the event of the failure of the river wall, by a surrounding filling of not less than fifteen feet width, and that roads shall also be up at a safe level.

The principal buildings divide into two categories: the two reactor buildings and associated boilers and gas circulators, and the turbine house with circulating water system for condenser cooling. The level of the pressure vessel of the reactor relative to the boilers is set by gas circulation requirements. The clay site for founding dictated that the plant should be on a common raft to minimize differential movement. The required arrangement of the plant, with the resulting fixing of vertical dimensions, gave the most acceptable level for the raft foundation, so that the ground surface level occurred at a convenient elevation relative to the plant. This factor had to be taken into account in choosing a position on the site for these principal buildings so that the raft level would be on clay with a bearing value compatible with the loading.

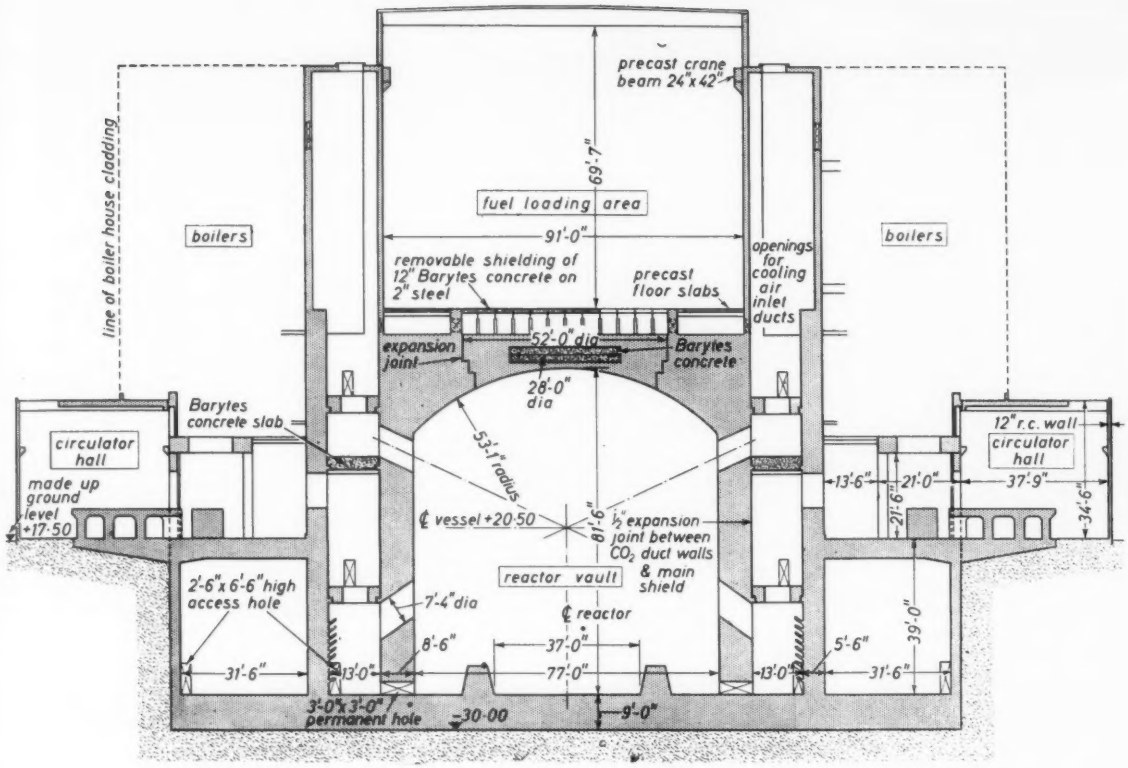
The level of the turbine house is established by the fact that the level of the condenser outlet to the cooling water system is related to the tide levels in the estuary to give the optimum solution to pumping and capital costs. Again, a level so chosen had to be checked against clay bearing values at the resulting foundation levels so that undue civil costs would not be engendered.

The heavy lifting required in the erection of pressure vessels and boilers by Goliath crane makes it necessary for the two reactors buildings to be in line and reasonably close together. Placing the axis of the turbine house parallel to the centre line of the two reactors met the plant requirement of good geometry for cable, steam and feed runs. The distance between turbine and reactor buildings was fixed by considerations of space required for erection, permanent access and economy of pipe and cable runs.

Consideration of all the factors outlined above, together with a balance of dig and fill, resulted in choosing posi-



The subsoil at Bradwell is clay, so each reactor, together with its six boilers, is supported on a single massive concrete raft. The floor of this is 9ft thick and placing required excavation to an average depth of 40ft below existing ground level. View above floor level shows outline of biological shield, sphere and boiler supports



Elevation through reactor building shows shielding features. Boilers are in non-stressed glazed enclosures

tions on site for the main buildings as shown on the plans. The location of the ancillary buildings was fitted into this main pattern.

Reactor Buildings

A feature of a nuclear station is the shielding walls required round the pressure vessel and other radioactive parts of the plant to absorb radiation. At Bradwell these walls are various thicknesses up to ten feet and are to be constructed of concrete exceeding a specified minimum density. The six boilers associated with each pressure vessel, through which the gas is circulated for heat exchange, have to be maintained at correct relative levels with only a small margin for differential movement. Accordingly it was decided to place all this plant on a single raft. The raft for each set of reactor and boilers is 200 ft by 100 ft by 9 ft thick reinforced concrete. The excavation is 35 to 45 ft deep from existing surface and was carried out in open cut with side batters of one to one and with a temporary mass retaining wall 9 ft high at the toe. Concreting was carried out in eight strips for each raft across the full width in a sequence giving not less than fourteen days setting for adjacent bays before placing dumplings. The rafts for both reactors are now concreted.

Reinforced concrete retaining walls follow the periphery of the rafts up to ground level and are constructed integrally as cantilever walls for a temporary condition with some of the backfilling done. On completion of the structure slabs at ground level and the main biological wall, the retaining walls will carry loading of filling to final level by spanning vertically or, in some cases, in two directions.

The main shielding wall rises in a circular formation of 77 ft internal diameter to about 80 ft above raft level in various thicknesses between 8 ft 6 in. and 10 ft. A dome formation is adopted for shielding over the pressure vessel and forming the pile cap. Secondary shielding walls are formed by parallel sided straight vertical walls round the CO_2 ducts and are to a height of 156 ft above raft level in various thicknesses between 5 ft 6 in. and 2 ft.

On the control and fuel faces, buildings framed in reinforced concrete with concrete floors and brick panels are provided for housing the plant.

The boilers are carried on reinforced concrete stools and are surrounded with structural steel framing to carry galleries and the external glass cladding.

The two reactor buildings are similar to each other but are handed in most parts.

Turbine house

The six turboalternator sets are carried on reinforced concrete foundations going down to a suitable stratum of clay. The foundations below basement are pierced by the supply culverts for the CW system and one of the return culverts which run longitudinally in the turbine house. Care is taken in the design to avoid imposing any loads from the sets on to the culverts due to differential settlement.

The turbine house basement is about twenty feet below final ground level and is contained by reinforced concrete cantilever retaining walls. The main building structure is in steelwork of portal design and is carried on mass concrete foundations.

Circulating water system

The condenser cooling water system is designed for a maximum circulation of 900 cusecs. The CEA designated the location and level of the intake and outlet points in the Blackwater river and the length, height and position of the barrier wall to separate the flows in and out. The requirements were formulated after a hydrographic survey and tests on a model of the estuary had been completed

on their behalf by consulting engineers.

The Authority further required that the system should be arranged so that any section could be made available for inspection and maintenance without shut down of the station although some reduction below maximum load could be accepted. Accordingly intake and outlet shafts are in duplicate, are grouped together and each pair separated by a barrier to prevent recirculation. The shafts are basically similar to each other and each is formed by a circle of steel piling supported internally by reinforced concrete diaphragms and walings. Openings are provided in the shafts from cill level to a height below low water and protected by guard screens.

In each circle of piled chamber a circular shaft is sunk and lined with precast concrete tubbing, later to be covered in an *in situ* concrete lining. These shafts go down to a level for tunnel driving with a suitable clay cover.

The intake shafts connect by tunnel to a pump house located between the turbine house and the river wall. The pump house contains six axial flow vertical spindle pumps in three separate dry compartments. The suction of each pump is in a chamber which connect in two sets of three via penstocks to two suction chambers containing coarse screens and a vertical supply shaft connecting to the supply tunnel. This arrangement of pump suctions, screens and shafts has been examined in extensive model tests to check on formation of vortices and to obtain even water distribution.

The CW pumps discharge to twin pressure docks feeding the two reinforced concrete supply culverts which pass under the basement floor of the turbine house, as previously described, with cast iron feed mains taken from both culverts to each condenser. Discharge from the condensers is carried to the discharge shafts by reinforced concrete culverts under turbine house basement floor level, leading to syphon recovery pits, adjacent to the pump house. These pits contain circular weirs discharging to shafts connected by tunnel to the outlet shafts in the river in a manner similar to the intake.

The system is equipped with penstocks so that any portion may be isolated and dewatered for inspection.

A site inspection staff is responsible for seeing that standards of construction are maintained and a close control on concrete quality is imposed, assisted by a site concrete testing laboratory. It is planned to complete the works in an overall period of four years.

BRADWELL REACTOR VESSELS

design, fabrication and erection problems

R. F. BISHOP MA, AMIMechE

Chief Engineer, Special Developments, Whessoe Ltd

THE DESIGN of heavy pressure vessels, such as those for containing the reactors at Bradwell, involves a considerable amount of specific stress analysis and other more or less theoretical work. But the first of the more general problems is the selection of a steel, which must be suitable for site-welding in thick plate form and for withstanding the high temperature working conditions.

What is needed in a steel

The high temperature requirements can be specified in terms of creep performance and stress to rupture properties, together with the necessary resistance to oxidation by carbon dioxide at high temperatures.

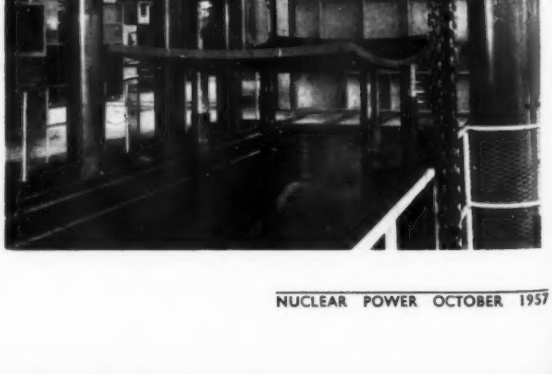
The requirements for welding thick vessels in the field are less precise. In addition to good welding characteristics, it is most important that the steel has good notch ductility at quite low temperatures. This requirement is partially to prevent the propagation of cracks during the construction and in particular during the air test of the vessels. It is also needed since the neutron bombardment of the pressure vessel during service tends to embrittle the steel and a large reserve ductility is, therefore, most advisable. The Bradwell pressure vessels will be fabricated partly from *Bearcomo*—a development of the *Lowtem* used at Calder with better high temperature properties—and partly from a silicon-killed version of *Lowtem*. Each plate is ultrasonically tested over its entire area for laminations or other flaws.

Forming the plates

The first major works operation is the pressing of the plate to a spherical form. The size and thickness of these plates takes this operation out of the normal capacity range of the plate bending presses in this country. Whessoe Ltd, the manufacturers of the first eight large pressure vessels for nuclear power stations, at Calder and Chapel Cross, were early aware of the need for greater pressing facilities and about three years ago approached Fielding & Platt Ltd, to design and make a press for them, to meet present and future requirements.

The press, now built and working, has a capacity of

Plates are formed in a new £500,000 integrated press plant at Darlington



The complete plant consists of charging machine, press and gas-fired furnace for raising the plates to 1000 deg. C

4500 tons and is capable of handling plates 25 ft long and 10 ft wide. A special plate furnace and plate handling bogie is used with this press. The complete unit, with the ancillary marking and cutting facilities, provides what is believed to be the finest integrated pressing facility in the world.

After pressing, the plates are marked out in a special building, using a patented shadow projection technique to ensure the greatest possible accuracy in sizing. The plates are then cut to size in another special building, using a triple flame-cutting head mounted on the end of a long pendulum which is pivoted at a height above the plate equal to the final radius of the sphere. This equipment can be adjusted to cut segments of various radii.

These special facilities are necessary in order to provide the requisite extremely accurate plate fit-up and accurate shape for these large vessels. It will readily be appreciated that inaccurate sizing of plates, resulting in varying gaps during erection, will lead to welding and distortion troubles.

Site prefabrication

In the field, the plates are machine-welded together in panels on specially built manipulators, and then assembled into rings and completely welded up in a prefabrication area on the ground. The entire site area for the prefabrication of the large sections is served by a Goliath crane of 40 ton capacity or by the main 200 ton Goliath crane. By prefabricating these large sections outside the biological shield, it is possible for work to proceed on this structure unimpeded by work on the pressure vessel.

It is also possible to perform more separate operations simultaneously by working on a number of rings on the ground than on rings placed one above the other inside the confined space of the biological shield. Again, by prefabricating it is possible to take advantage of the use of automatic welding equipment on a very large scale. At the present time, it would be very difficult indeed to do this with the plates in the finally erected position.

To obtain these advantages, it is necessary to lift large sections of the prefabricated vessel weighing anything up to 200 tons. This is done by the main Goliath crane, which was designed largely for lifting these sections and the complete boiler vessels.

Erection inside the vault

Inside the biological shield there is still a great deal of work to do on the vessel. The circumferential seam between each of the rings has to be welded and radiographed before the next ring is lifted into position. There is also a considerable amount of erection and welding work involved in the internal fairings and in placing the diagrid graphite support in position.

One of the greatest savings in time by prefabrication is gained in the welding into position of the standpipe nozzles in the top crown. This is carried out on the ground inside a covered building. Such an arrangement ensures the very best possible conditions for marking out and cutting the holes and for welding the heavy standpipe reinforcing forgings into position. The necessity for accurate positioning and high quality workmanship in this part of the job makes it one of the key operations in the construction of the reactor pressure vessels. A precise welding procedure has been drawn up for these vessels. All the seams will be examined radiographically.

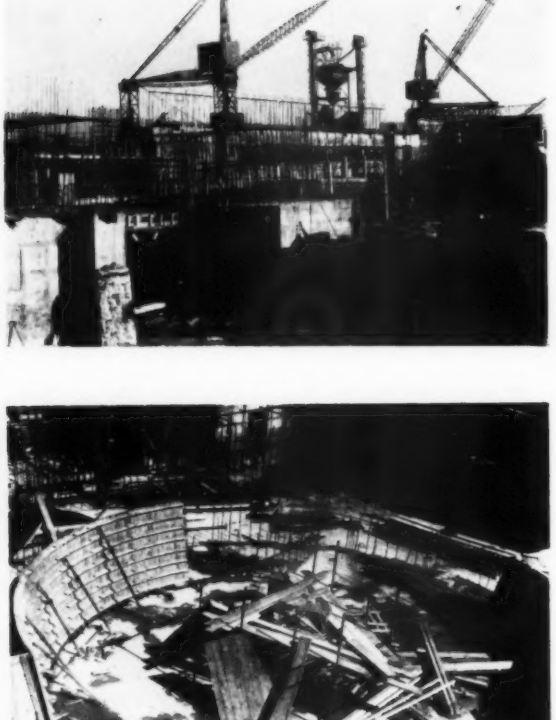
Stress relieving and pressure testing

When the vessel is complete, it is stress-relieved in position. For this operation, insulation is applied outside and a mesh of stainless steel tubing erected inside the vessel. Through this mesh a very high current is passed to produce an enormous radiant electric fire—more than 2 MW of power are needed to provide the necessary heat. This method of stress relieving large vessels in the field was pioneered by Whessoe for the building of the heavy reactor vessels at Calder.

After stress relief the external insulation is removed and an air test applied to the whole vessel with the standpipe openings blanked off. Such a test is a complicated affair, with several hundred strain gauges attached at key parts of the construction. A large number of observations of deformation and movement are taken. After the completion of the pressure test, the standpipes are placed into position. During this phase of the vessel's construction, a large number of different contractors are working in an extremely confined area. The pile cap sequence of erection is therefore a most carefully dovetailed plan, involving the positioning of the standpipes and the erection of the top thermal shield and the top part of the biological shield.

1

2



3

4

BRADWELL

IN DECEMBER 1956, the Nuclear Power Plant Co Ltd was awarded a contract by the Central Electricity Authority for the design and construction of a nuclear power station which guaranteed an output of 300 MW. The site chosen was Bradwell-on-Sea, Essex, on the right bank of the Blackwater estuary. Mr A. Young, Chief Resident Engineer, is in charge of the site.

Civil engineering operations, by Sir Robert McAlpine and Sons Ltd, commenced early in 1957, the main efforts being concentrated on the excavations for the turbine hall and the reactors.

After this initial preparatory work, the tempo of construction accelerated. By the end of August—at which date this report is effective—all targets set had been reached or improved upon.

Turbine hall Most of the excavation work is complete and the outer retaining walls are taking shape. At basement level, foundation blocks for the main and auxiliary turboalternators are being poured, the circulating water culverts are under construction and progress is being made on the basement flooring to allow early erection of the main steelwork by Alex Findlay & Co.

Reactors The outer walls of No 1 Reactor are at ground level and the main floor raft is complete. At each end of the reactor bay, the support structures for the boilers are nearing the level of the outer walls. In No 2 Reactor the floor raft is finalized and parts of the outer wall are cast. Shuttering is being erected for the remaining structures.

Goliath crane With a clear span of 167 ft, the Goliath crane will bridge the reactor blocks and will run on rails along the complete length of these two buildings. Two

1 Turbine foundation blocks are being prepared. **2** Outer retaining walls of the turbine house begin to rise. **3** No 1 is the more advanced of the two reactor sites. To the right is a completed section of the sphere plinth: to the left shuttering is ready for another segment. **4** At No 1 Reactor again the walls are nearly at ground level. **5** At No 2 Reactor site reinforcing rods are in position for the outer walls, boiler supports and reactor pressure vessel

5

hooks will be provided, the main one having a lift of 200 tons, and the auxiliary one a lift of 30 tons. Hook clearances, respectively, are 144 ft and 148 ft. The completed Goliath will be used to hoist sections of the reactor pressure vessels from the fabrication area and to install complete boiler shells.

A J-crane has been used to build a steel tower on which the main and auxiliary girders of the Goliath are located during the erection period.

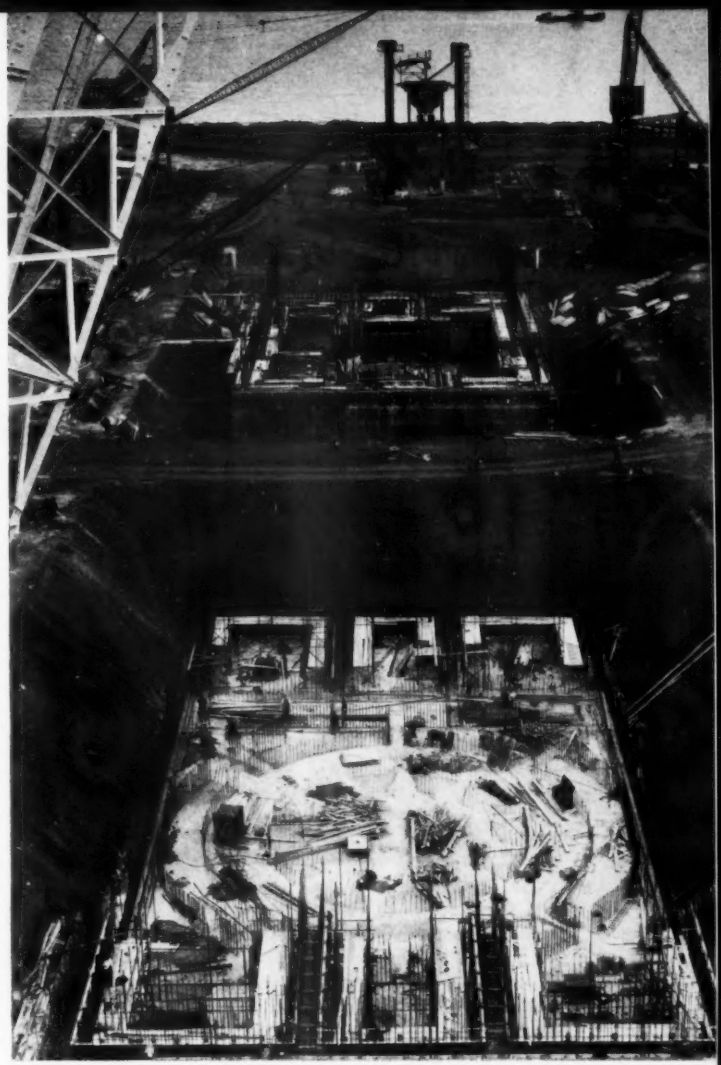
At the end of August, the tower carried the main centre section and intermediate girders (outriggers not yet positioned) and one auxiliary girder. On the ground, some 400 ft of track, set in reinforced concrete, had been laid for the Goliath bogies. Three of the four bogie sets were in position, the fourth one being prepared. The final track length on each side will approach 1200 ft.

Pressure vessel fabrication area On the east side of the Goliath structure is the completed area for the fabrication of the reactor pressure vessels by Whessoe Ltd. From here the Goliath will remove the welded sections and locate them in the reactor buildings.

C.W. Pump house Excavations are well advanced for the circulating water pump house which is located on the north side of the turbine hall.

Temporary jetty Beyond No 1 Reactor, a temporary jetty extends approximately 400 feet from the sea wall into the River Blackwater. This structure, which is complete, is suitable for off-loading materials during all conditions of tide. One of its jobs will be to receive the special aggregate required for the high density biological shielding around the reactors.

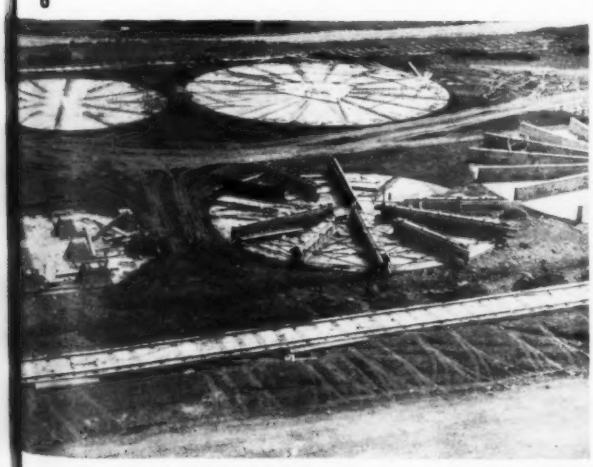
PROGRESS



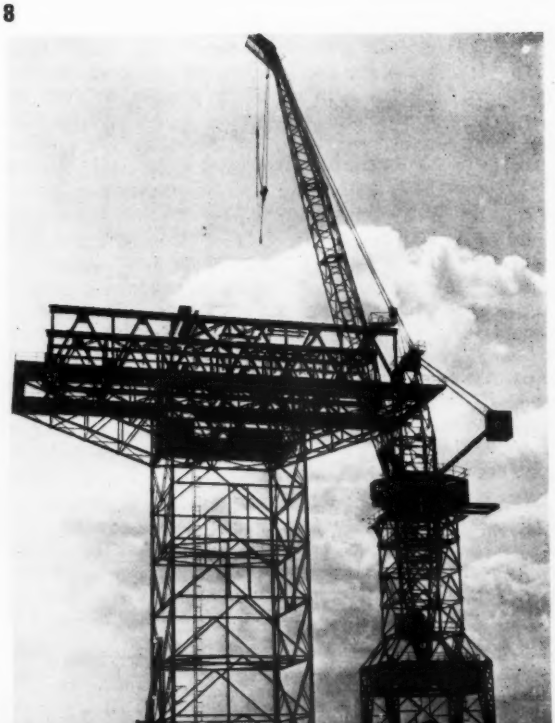
7

plinth. 6 The pressure vessels will be fabricated on these concrete standings. Rails are for the Goliath crane which will span complete reactor building. 7 From a crane general progress of reactor site is clear. No 2 nearest camera. Note batching plant beyond No 1. 8 A J-crane and steel tower are being used to erect the Goliath crane. Here the main centre section and intermediate girders are already in position on the tower. *Photos: John Hutchen*

6



8



Britain plans to have a total installed nuclear generating capacity of 6000 megawatts by 1965. Four stations are now building: here is a description of one of these

BRADWELL NUCLEAR POWER ST

ONE OF THE Central Electricity Authority's first two nuclear power stations is that now under construction by the Nuclear Power Plant Company at Bradwell-on-Sea, Essex. Work at the site started early in 1957 and the station is due for completion by the end of 1960. Based on the very successful Calder Hall natural-uranium, gas-cooled, graphite moderated system, Bradwell will have two reactors and six turboalternators providing a guaranteed net output to the National Grid of 300 MW.

The site is on the right bank of the River Blackwater just before it runs into the North Sea. The main features are planned in two separate masses—the two reactor buildings which are joined at a low level and the turbine house which is linked to the ancillary buildings. Compactness is an important feature and although the site acquired by the CEA covers 142 acres, the area within the security fence is only about 18 acres.

Circulating water is drawn from the River Blackwater and for economical design it was decided to build the turbine house at right angles to the shore with the axis of the two reactor buildings parallel to this to the east.

The two reactors are identical but their buildings are in the main opposite handed so a description of one will serve for both.

The reactors

The pile consists of a 24-sided prism of graphite blocks 45 ft dia and 31 ft high some of this being accounted for by the neutron reflector graphite. The actual core containing the fuel channels is 40 ft dia and 25 ft 8 in. high and is thus surrounded on all sides by about 2·5 ft of reflector. Graphite of nuclear grade (cross-section, less than 4 millibarns) is used for the core proper, with material of lower grade for the reflector. In all, construction of each pile will need graphite blocks of 43 different shapes and the total weight as installed will be about 1910 tons. These blocks have to be very accurately machined to minimize neutron leakage along the joints and yet allow a measure of Wigner growth under irradiation conditions.

As in all British stations, the fuel channels are vertical and at Bradwell there will be 2,575 of them—rather less than comparable designs. Counting holes for control rods, neutron absorbers and flux scanning, the total number of channels will be 2,837. The diameter of every channel will be the same and their centrelines will be on an 8·00-inch square lattice. From nuclear considerations, it is in fact undesirable to depart very far from this figure with a natural uranium and graphite system and all British stations and even the French reactors at Marcoule use lattice modules very close to 8 inches.

The natural uranium bars will be 1·15 in. dia, 36 in. long and will be sheathed in helically finned cans of *Magnox* A12 alloy. There will be eight of these elements in each channel and the designers have rejected separate support for each one in favour of straightforward stacking one above the other with continuous lateral restraint. Channel entries will be fitted with gags by means of which the gas flow in particular channels will be adjusted to the optimum. The foot of the lowermost elements will be supported by a special fitting direct to the grid through a ball bearing. With eight elements to the channel and uranium at 0·675 lb/in^3 the total weight of fuel per reactor is about 240 tons.

To secure a flattening of the neutron flux distribution curve across the core the reactor will use a system of neutron-absorbing elements of special steel. This results in a high value of the ratio maximum/mean flux and improves the burnup, a figure of 3,000 MWD/t being anticipated. As burnup proceeds these absorbers, which will

Principal nuclear and

OUTPUT
Two reactors—each 531MW heat
Installed generating capacity 6 × 52MW plus 3 × 20·5MW at design steam conditions
Guaranteed net output—300MW

FUEL
Material—natural uranium rods
Dimensions of element—1·15 in. dia × 36 in. long
Elements per fuel channel—eight
Elements per reactor—20,600
Uranium per rod—25·7 lb
Total uranium per reactor—240 tonnes
Canning material—Magnox A12 alloy
Element support—stacking

MODERATOR
Material—reactor-grade graphite
Form—24-sided polygon
Core—40ft dia × 25ft 8in. high
Number of fuel channels—2575
Number of control rod channels—120
Type of lattice—square, 8in. pitch
Total weight of graphite—1910 tonnes
Graphite support—bearings on steel grid

CONTROL RODS
Material—boron steel
Number for control—108
Number for shut-off—12
Reactivity invested in rods—7·0%
Drive—variable-frequency induction motor

NUCLEAR DATA
Maximum thermal neutron flux—2·76 × 10^{13} neutrons/cm^2/sec
Flux flattening—by steel rods
Burnup—minimum 3000 MWD/tonne
Conversion—0·85
Built-in reactivity cold, unpoisoned—4·9%
Temperature coefficient of activity—moderator: $-4{\cdot}4 \times 10^{-5}$/°C
uranium: $-2{\cdot}3 \times 10^{-5}$/°C

PRESSURE VESSEL
Mean diameter—66 ft 9in.
Thickness 3 in. and 4 in.

STATION

be similar in form to fuel elements, will be transferred to the most advantageous positions to maintain the reactor performance. At a cost of £20,000 a ton for natural uranium, it is seen that the initial fuel charge for Bradwell—and the other first round stations too, for that matter—will be nearly £M10.

The initial built-in excess reactivity of the reactor will be 4·9 pct and the maximum thermal flux will be of the order of 3×10^{13}.

The pressure vessel

One, though not the only, factor which has enabled Bradwell to be over three times as powerful as Calder Hall is the fact that it is now considered perfectly feasible to weld 4 inch steel plate for the top of the reactor vessel at site. The Bradwell designers took full advantage of this to increase the size of the core and also the gas working pressure. Of spherical form, the pressure vessel is 66 ft 9 in. dia with a plate thickness of 3 inches, increased to 4 in. where required for reinforcement round openings. This will be fabricated at site by welding hot-pressed plate sections from the makers' works. The materials to be used are special alloy steels with good creep resistance at high temperature combined with satisfactory low temperature notch ductility.

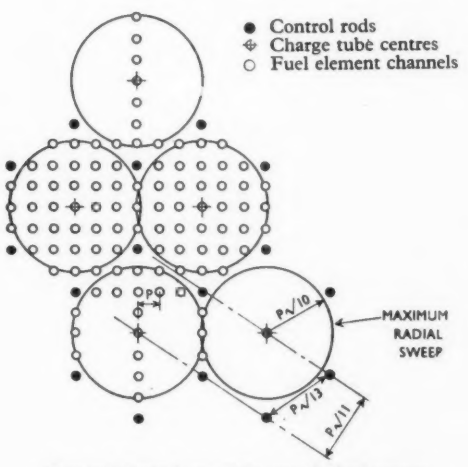
Below the vessel, there are twenty-four support legs mounted on a massive concrete ring on the foundation raft. These supports allow a degree of freedom for thermal movement and continue inside the pressure shell to pick up the core support grid. In this way the weight of core and fuel—some 2,300 tons—is taken right through the shell to the ground without imposing any load on the former.

The core support grid is of cellular construction in welded steel fabrication, the cells being 5 ft 4 in. square in plan. On the grid are placed cast steel support plates perforated with 64 holes matching the fuel channels. The weight of the graphite is transferred to the support plates by means of steel balls which allow for relative expansion of graphite and steel.

Above, the core is completed by charge pans each consisting of a rectangular steel casting provided with 18 tapered holes matching the fuel channels. For charging purposes the channels are grouped in 37's except round the periphery where, owing to the radius, there are incomplete groups.

Charging system

The fuelling system is similar in principle to that used at Calder Hall but is complicated by the fact that charging and discharging are done without shutting down the reactor. It is also done through separate standpipes independently of the control rods. The charge tube is attached to the charge machine and located at its lower end in the centre hole of the channel group. A new element is now lowered to the bottom of the charge tube on a cable



Control channels are right outside fuel groups

fitted with a special grab. The lower part of the tube is movable radially by means of a parallel linkage mechanism and it is then extended and rotated to reach any particular channel. The element is then lowered cleanly through the charge pan into the channel, and when in

engineering data

SHIELDING
Material—reinforced concrete
Thickness—9–10ft
Cooling—once-through induced draught

COOLANT
Material—carbon dioxide
Static pressure—10atm
Inlet temperature to reactor—180°C (356°F)
Outlet temperature from reactor—390°C (734°F)

GAS CIRCULATION SYSTEMS
Ducts—six inlet and six outlets per reactor, 5ft dia
Blowers—six, axial flow
Speed—600/3300 rpm
Drive—variable frequency induction motors supplied from 3 (1 standby) auxiliary 20·5MW turboalternators

BOILERS
Number per reactor—six
Dimensions—19ft dia, 87ft high
Heat exchange tubing—Integron finned
Sections—l.p. economizer, evaporator, superheater
h.p. economizer, evaporator, superheater
h.p. steam conditions—770psia, 704°F (373°C)
l.p. steam conditions—210psia, 704°F (373°C)
Feed heating—2 stages
Final temperature—190°F

POWER PLANT
Main turbines—six, impulse-reaction
Maximum continuous rating—52MW 5% margin
Speed—3000 rpm
Generator voltage—11·8kV
Steam conditions at stop valves: h.p.—745 psia, 700°F (371°C)
l.p.—195 psia, 700°F (371°C)
Auxiliary turbines—three 20·5MW (1 standby)

STEAM DUMPING
Dump condensers fitted for disposing of surplus steam when reactors are shut down or during start-up

place released from the grab. Discharging uses the reverse procedure.

Fuel element charging and discharging will be done by a special machine which performs both operations. Weighing 300 tons, largely on account of the shielding, this runs on wheels along a gantry which in turn traverses the charge floor. A second machine is provided as a standby unit. As operations will be done under load the machines are pressurized to the full reactor pressure. Control will be entirely remote and will be carried out from a special control room situated above the charge floor. Charge plugs and charge tubes are kept in shielded stowages accessible from the pile cap and they are extracted and inserted into the reactor by the charge machines.

Upon discharge from the reactor the irradiated elements will be lowered under shielded conditions down a shaft to below ground level and from thence through a subterranean tunnel under the roadway to the storage pond in a long low building just alongside.

Control of the reactor will be by boron steel rods running in vertical channels through the core. A total of 120, each with its own standpipe will be used and of these, 108 will be for control, 12 for safety. Variable frequency motor actuators, improved versions of the Calder ones, will operate the rods by cable.

The boilers

The heat exchange system is laid out in a very compact plan with each reactor's six boilers disposed equally on either side and included within the reactor buildings inside glazed enclosures. The boiler shells are 19 ft dia and 87 ft high. They include economizer, evaporator and superheater sections for both high pressure (770 psia, 704°F) and low pressure (210 psia, 704°F) steam. The heat exchange tubing except for the superheater sections, is *Integron*, integral finned and the station will use about 200 miles of it.

Immediately below each boiler an axial-flow blower is mounted with its axis horizontal; this is a single stage machine with the diffuser section coaxial with the impeller. The suction inlet is on top of the casing and connects directly through a bellows expansion joint with the outlet from the base of the boiler. The impeller is overhung and so only one gas seal is needed. This will be an oil-lubri-

This is how the Bradwell reactor works

The power station will have two nuclear reactors (1) and (2) in which the heat is generated to provide steam for the machines in the turbine hall (4). These will provide at least 300 megawatts to the National Grid. The heart of any reactor is the core (12). This is a huge cylinder of nearly 2000 tons of accurately made graphite blocks incorporating a large number of holes running from top to bottom. These serve to contain the nuclear fuel elements (13) which are uranium rods hermetically sealed in magnesium alloy cans with fins on the outside. When enough fuel is assembled in this way—there will be 240 tons in each reactor—it becomes critical and begins to give out heat. The rods are kept cool by the carbon dioxide gas which is constantly circulated through the fuel channels and flows over the element fins. The whole core is contained in a huge spherical shell designed to contain the gas at high pressure.

On leaving the core the hot gas now flows through the duct (36) to the six boilers or heat exchangers (52) entering at the top and flowing downwards to the gas circulators (51) which are driven by electric motors, and returned to the sphere through the inlet ducts (35). The boilers are filled with special finned tubing—some 200 miles of it will be needed at Bradwell—containing the water. This enters the tubing at the bottom of the boilers and flows upwards, eventually being turned into superheated steam by the hot gas from the reactor.

To keep the reaction under control at all times, a number of control rods (21) are used. These are attached to cables operated by special electric motors on the pile cap (19) and run in core holes. The effect of lowering a rod into the core is to slow up the nuclear reaction: if enough are operated it can be stopped altogether.

As the nuclear reaction proceeds, the uranium fuel becomes used up and the elements have to be replaced by new ones. This is done by the charging machine (26). First, the spent elements are extracted by lowering a special grab down the chute (20) and hoisting them up into the machine. Then the new ones are lowered in. When the elements come out of the core they are strongly radioactive and cannot be touched by hand or even approached. They are therefore remotely handled through an underground tunnel to the cooling pond in the long low building (3). There they will lie under water for about three months after which radioactivity has died away sufficiently for them to be removed from Bradwell and taken to a chemical processing plant.

While the reactor is working the vault containing the sphere gets hot and this would eventually damage the concrete if it were not kept cool. This is done by a ventilation system using the fans (46).

Like all British atomic power stations, Bradwell will be inherently safe owing to the basic characteristics of the reactors. In addition, most elaborate safety devices will be incorporated so that it will be protected against damage arising from any abnormal running.

REACTOR DRAWINGS IN THIS SERIES ALREADY PUBLISHED BY 'NUCLEAR POWER' INCLUDE—

1 Dounreay core 11" x 20" black and white (June 1956)

2 Dido 11" x 20" black and white (August 1956)

3 Calder Hall 11" x 20" black and white (October 1956)

4 Lido 11" x 20" black and white (February 1957)

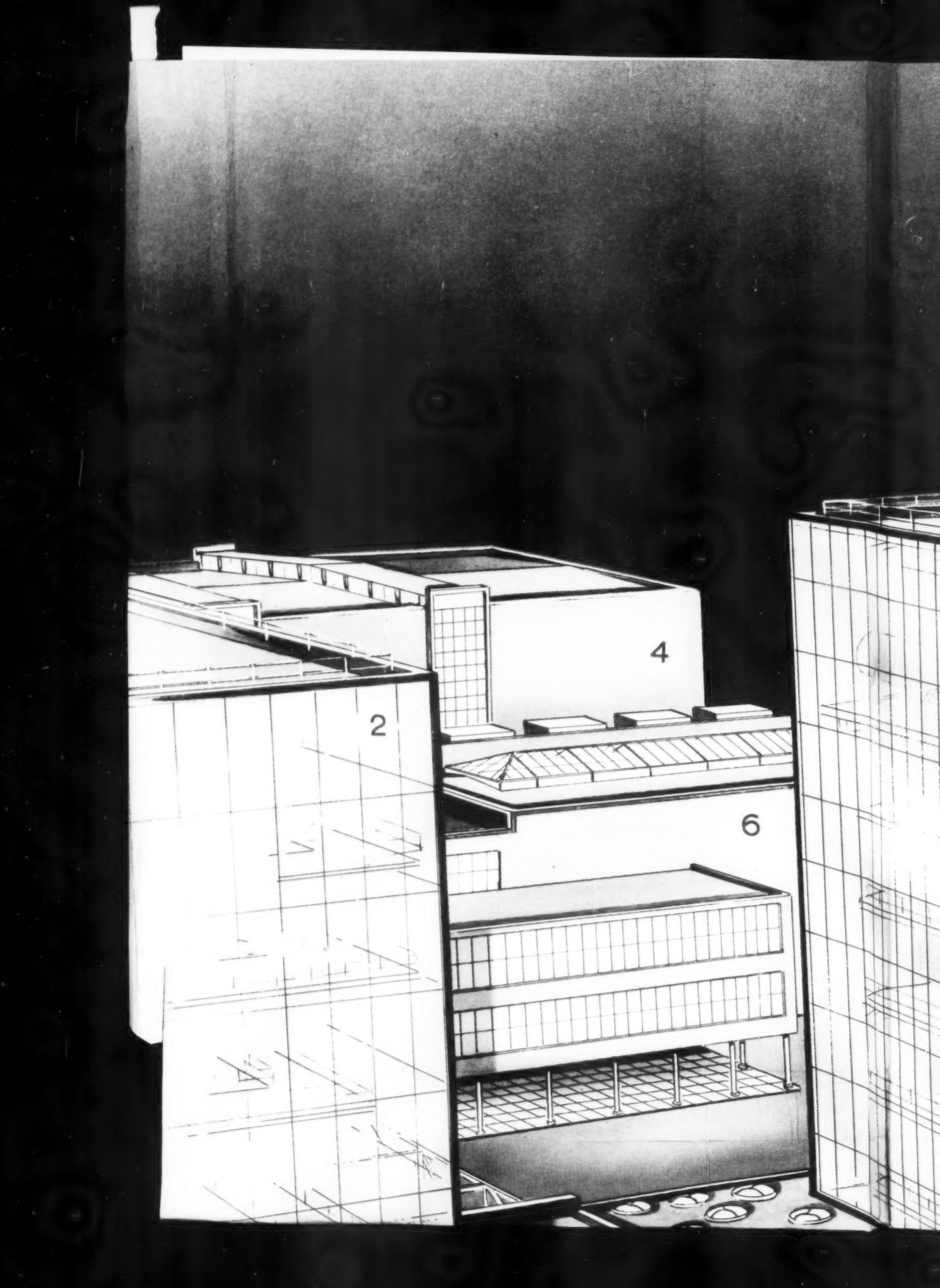
5 Berkeley 24" x 36" full colour (April 1957)

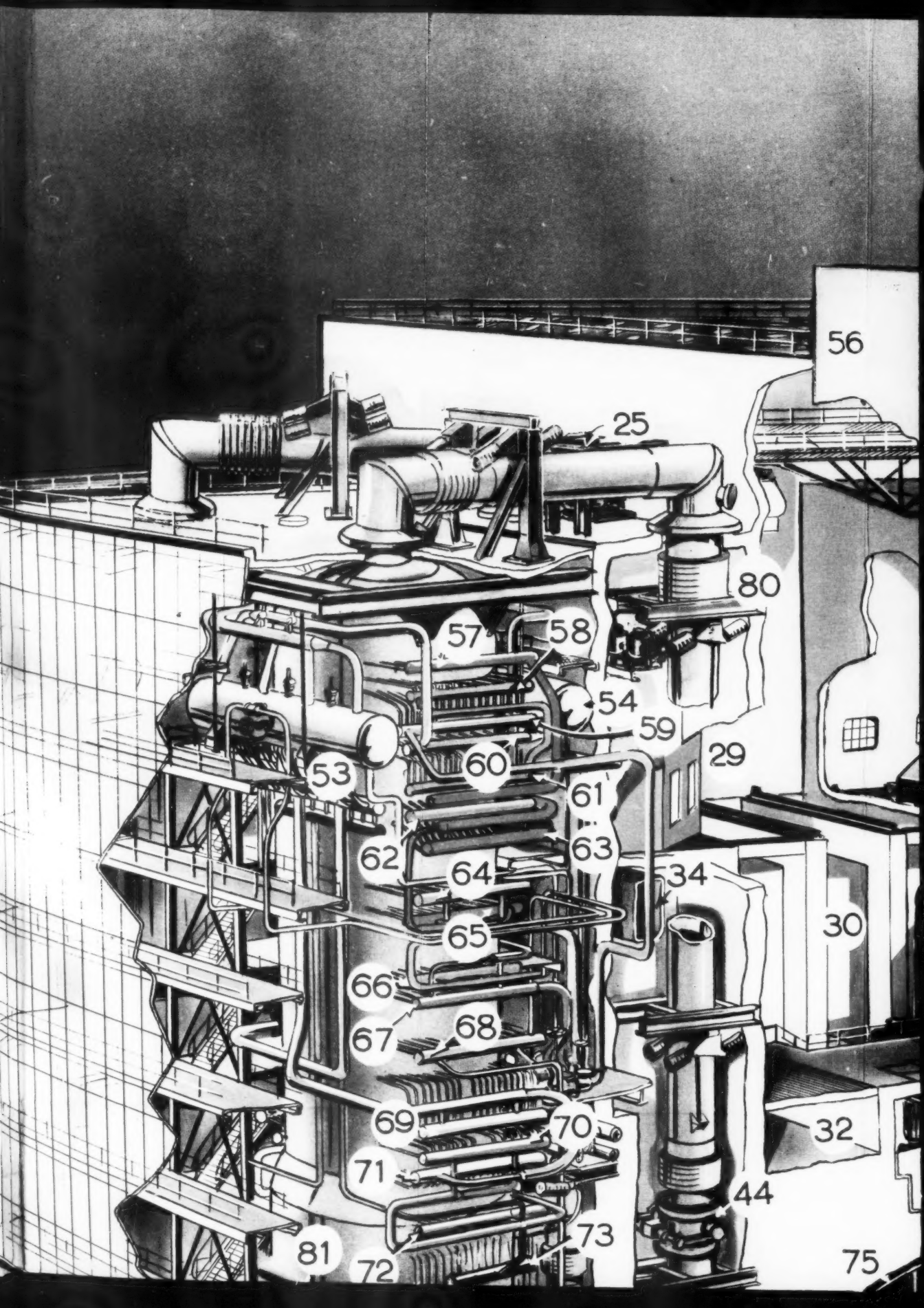
6 Dounreay 24" x 36" full colour (June 1957)

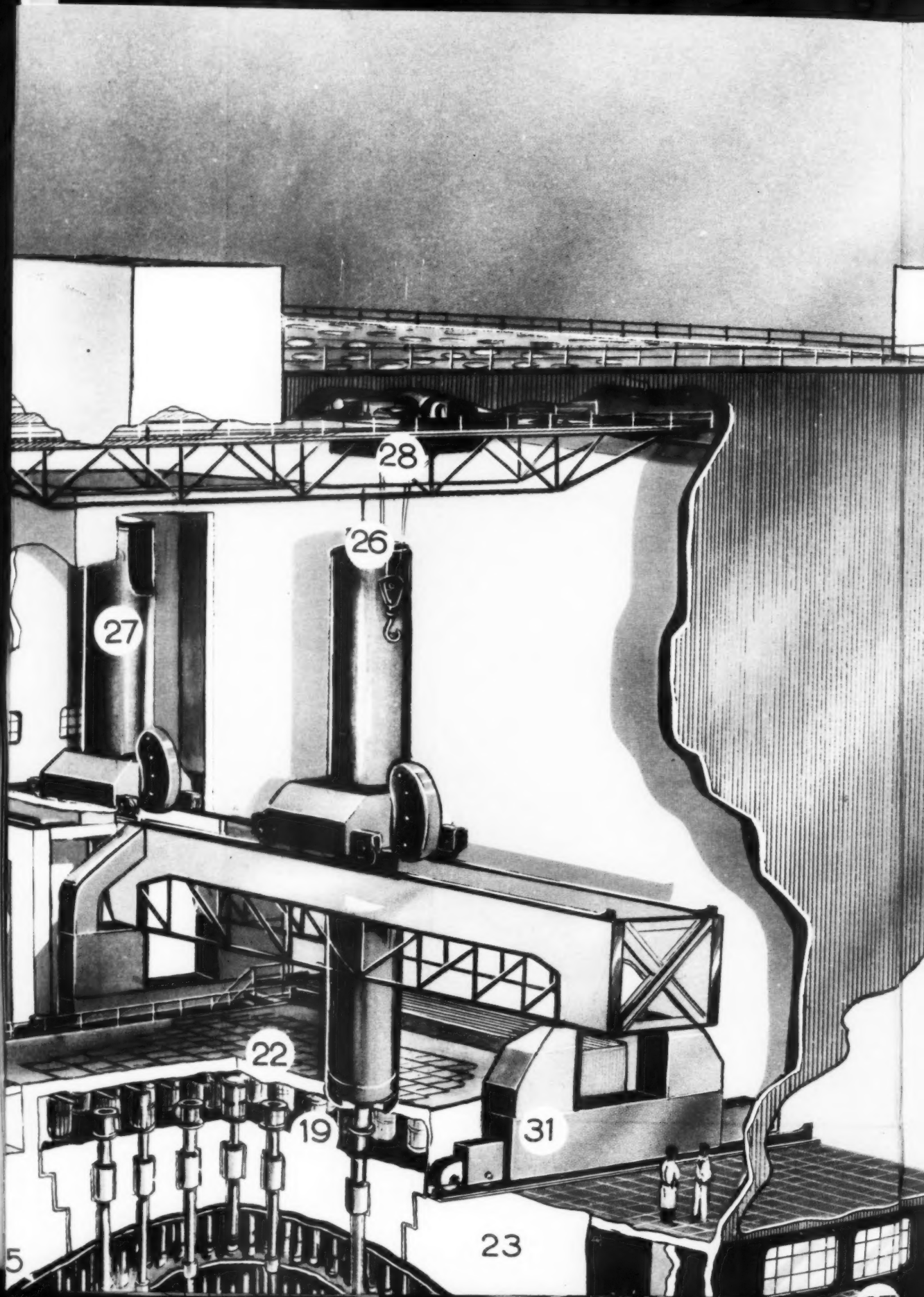
7 RWE closed cycle boiling water reactor 24" x 36" full colour (September 1957)

Limited copies of the large full colour drawing of Bradwell power station facing this page are available unfolded from NUCLEAR POWER, 3 Percy Street, London, W1, price 2/- + 6d postage and packing

XANTHOSYN


4
2
6

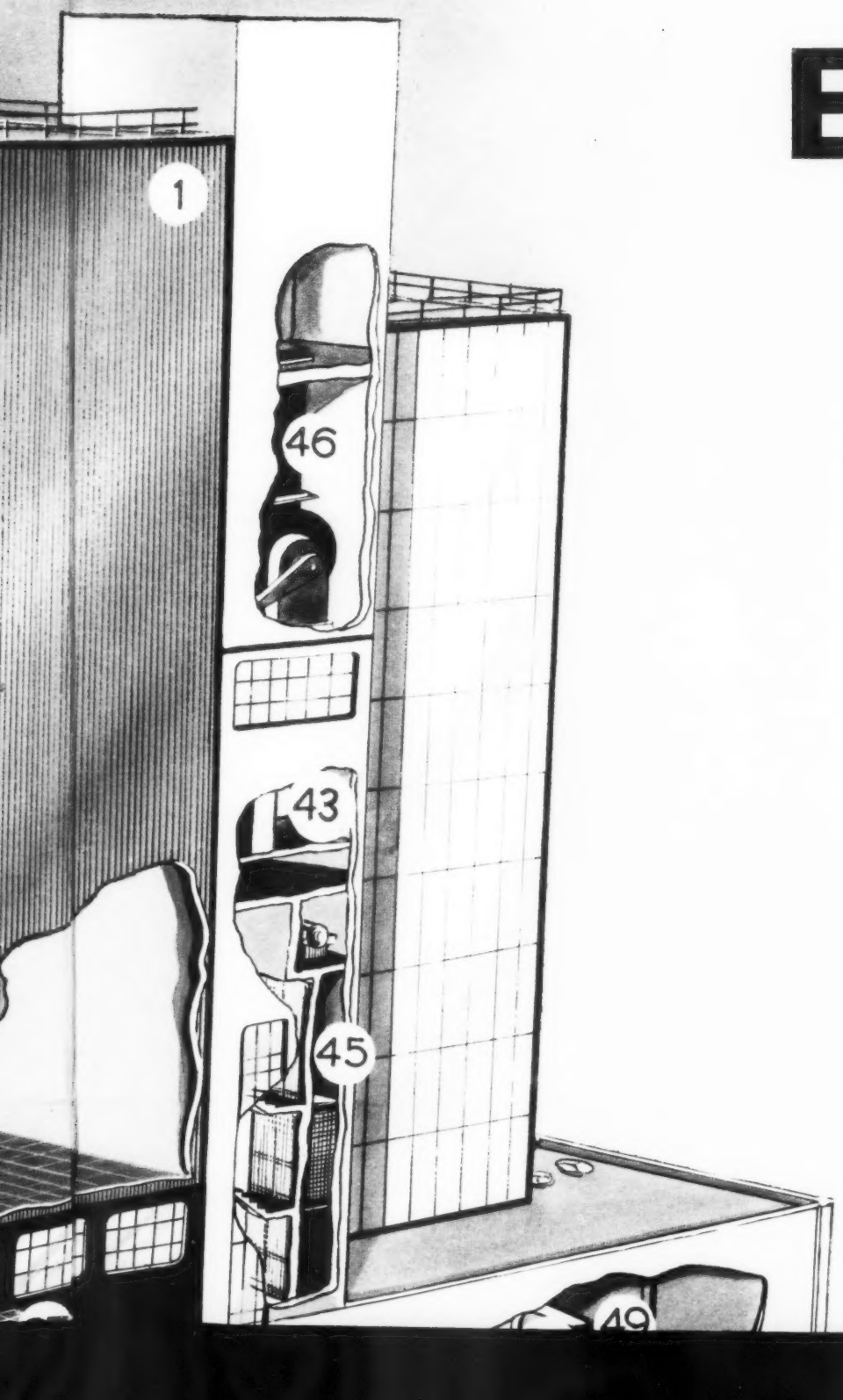

56
25
80
57
58
54
59
29
53
60
61
62
63
64
34
30
65
66
67
68
69
70
32
71
44
73
81
72
75


28
26
27
22
19
31
23
5

The Central Electr

BRAD

Nuclear



1 Reactor No 1
2 Reactor No 2
3 Cooling pond
4 Turbine hall
5 Workshop and sto
6 Auxiliary turbine h
7 Toroidal gas seal
8 Spherical pressure
9 Gas baffle
10 Core support grid
11 Support plates
12 Moderator bricks
13 Fuel elements
14 Roller supports
15 Charge pans
16 Gas seal
17 Reflector bricks
18 Fuel element supp
19 Pile cap
20 Charging chute
21 Control rods
22 Secondary floor
23 Biological shield
24 Access duct
25 CO_2 relief valves a
26 Charge/discharge
27 Standby charge/dis
machine
28 15 ton crane
29 Machine control ro
30 Parking bay
31 Charge/discharge
gantry
32 Storage space
33 Ventilation suctio
34 Ventilation suctio
35 Main CO_2 duct, in
36 Main CO_2 duct, ou
37 Fuel preparation ro
38 Fuel storage rooms
39 Manipulator room
40 Calorifier and pun
41 Hoist well

XU

entral Electricity Authority

BRADWELL

Nuclear Power Station

1 Reactor No 1
2 Reactor No 2
3 Cooling pond
4 Turbine hall
5 Workshop and stores
6 Auxiliary turbine hall
7 Toroidal gas seal
8 Spherical pressure shell
9 Gas baffle
10 Core support grid
11 Support plates
12 Moderator bricks
13 Fuel elements
14 Roller supports
15 Charge pans
16 Gas seal
17 Reflector bricks
18 Fuel element support
19 Pile cap
20 Charging chute
21 Control rods
22 Secondary floor
23 Biological shield
24 Access duct
25 CO_2 relief valves and filters
26 Charge/discharge machine
27 Standby charge/discharge machine
28 15 ton crane
29 Machine control room
30 Parking bay
31 Charge/discharge machine gantry
32 Storage space
33 Ventilation suction ring mains
34 Ventilation suction duct
35 Main CO_2 duct, inlet to reactor
36 Main CO_2 duct, outlet to boiler
37 Fuel preparation room
38 Fuel storage rooms
39 Manipulator room
40 Calorifier and pump chamber
41 Hoist well
48 Filter room crane (2 ton)
49 Main circulator and boiler instrument panels
50 Main circulator oil purifier
51 Main circulator (six per reactor)
52 Heat exchanger (six per reactor)
53 l.p. steam drum
54 h.p. steam drum
55 Circulator hall crane 10 ton
56 Reactor ventilation and filter ducts

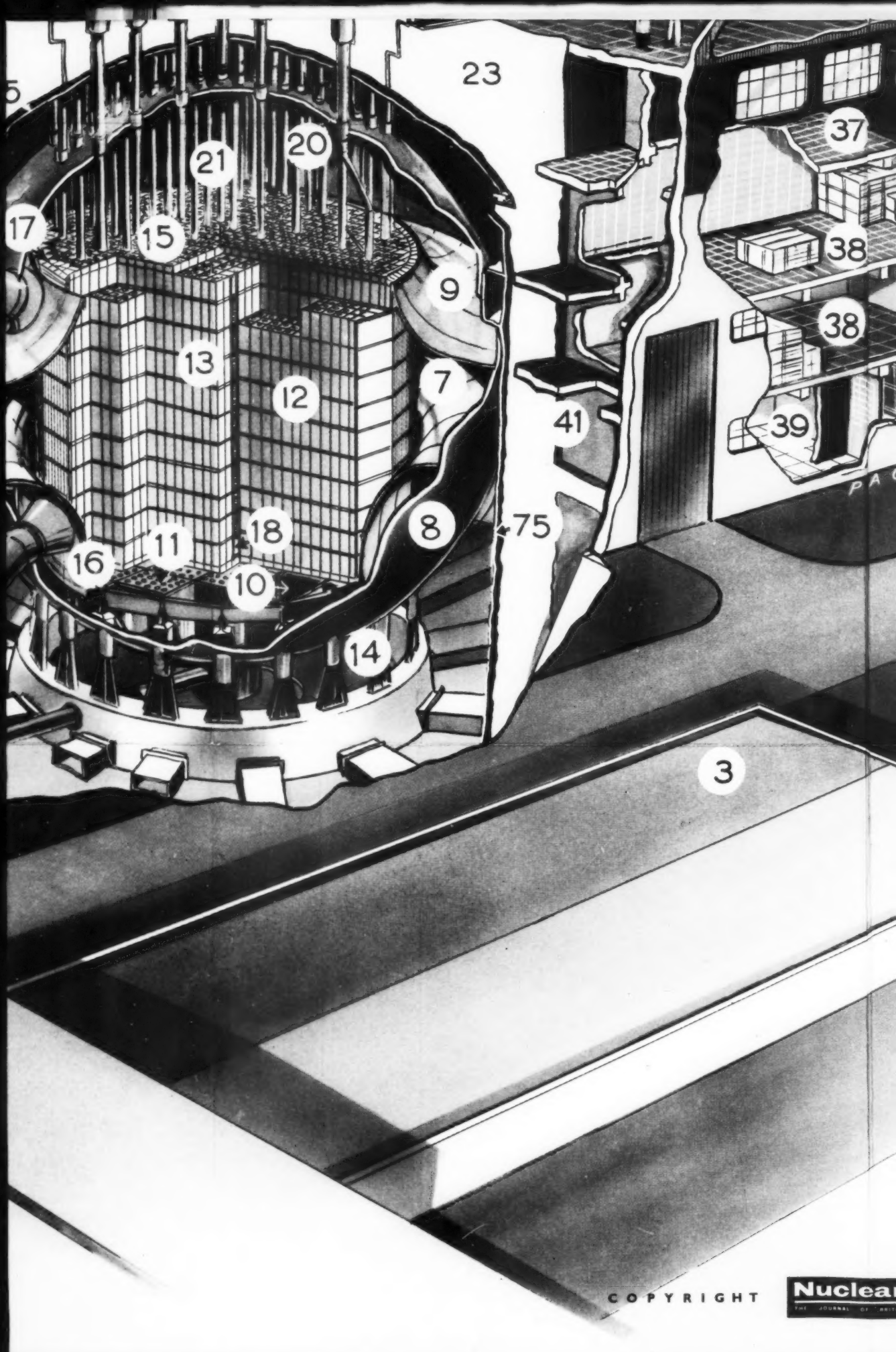
Boiler headers

57 h.p. superheater secondary outlet
58 h.p. s/h secy. inlet
59 l.p. s/h outlet
60 l.p. s/h inlet
61 h.p. s/h primary outlet
62 h.p. s/h pmy. inlet
63 Upper h.p. evaporator outlet
64 upr. h.p. evapr. inlet
65 Lower h.p. evapr. outlet
66 lr. h.p. evapr. inlet
67 h.p., h.t. economiser outlet
68 h.p., h.t. ecnr, inlet
69 upr., l.p. evapr. outlet
70 upr., l.p. evapr. inlet
71 lr. l.p. evapr. outlet
72 lr. l.p. evapr. inlet
73 l.p. ecnr. outlet
74 h.p., ecnr. outlet

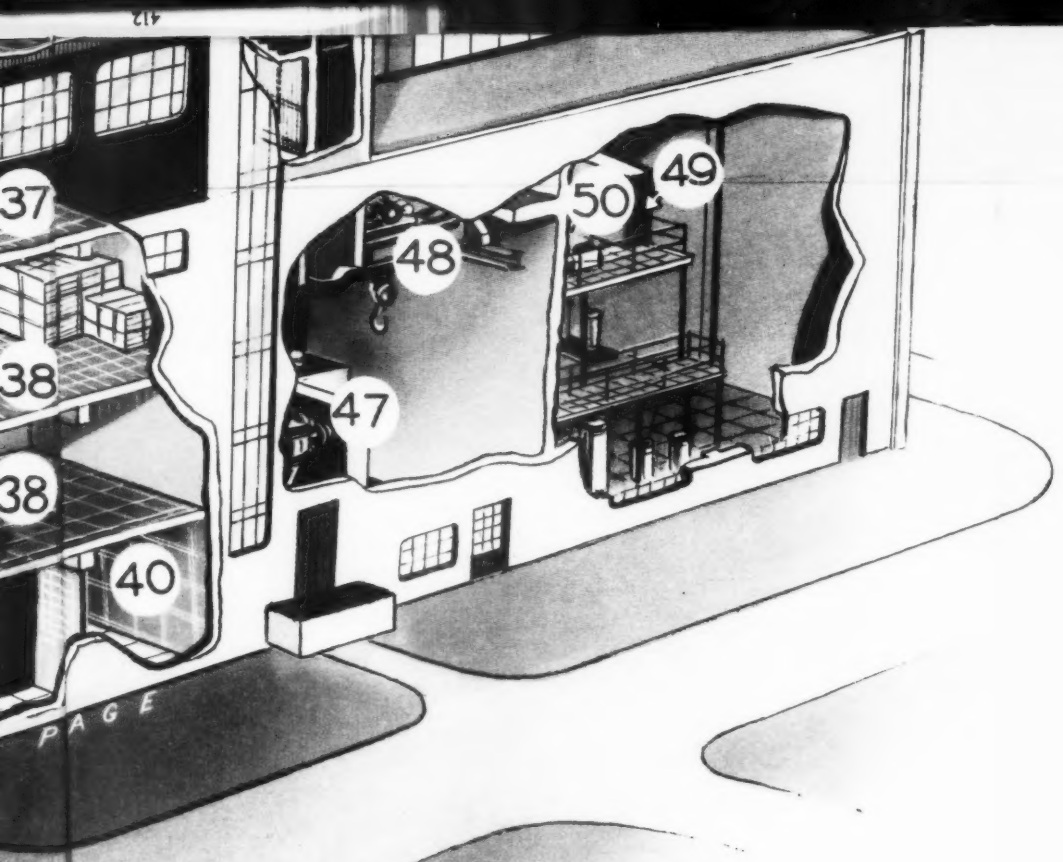
75 Thermal shield
76 Low pressure boiler circulating pumps
77 Main circulator oil tank
78 Main circulator lubricating and seal oil cooler
79 Main circulator lubricating and

55
83
7
76
82
49
78
79

XU



COPYRIGHT



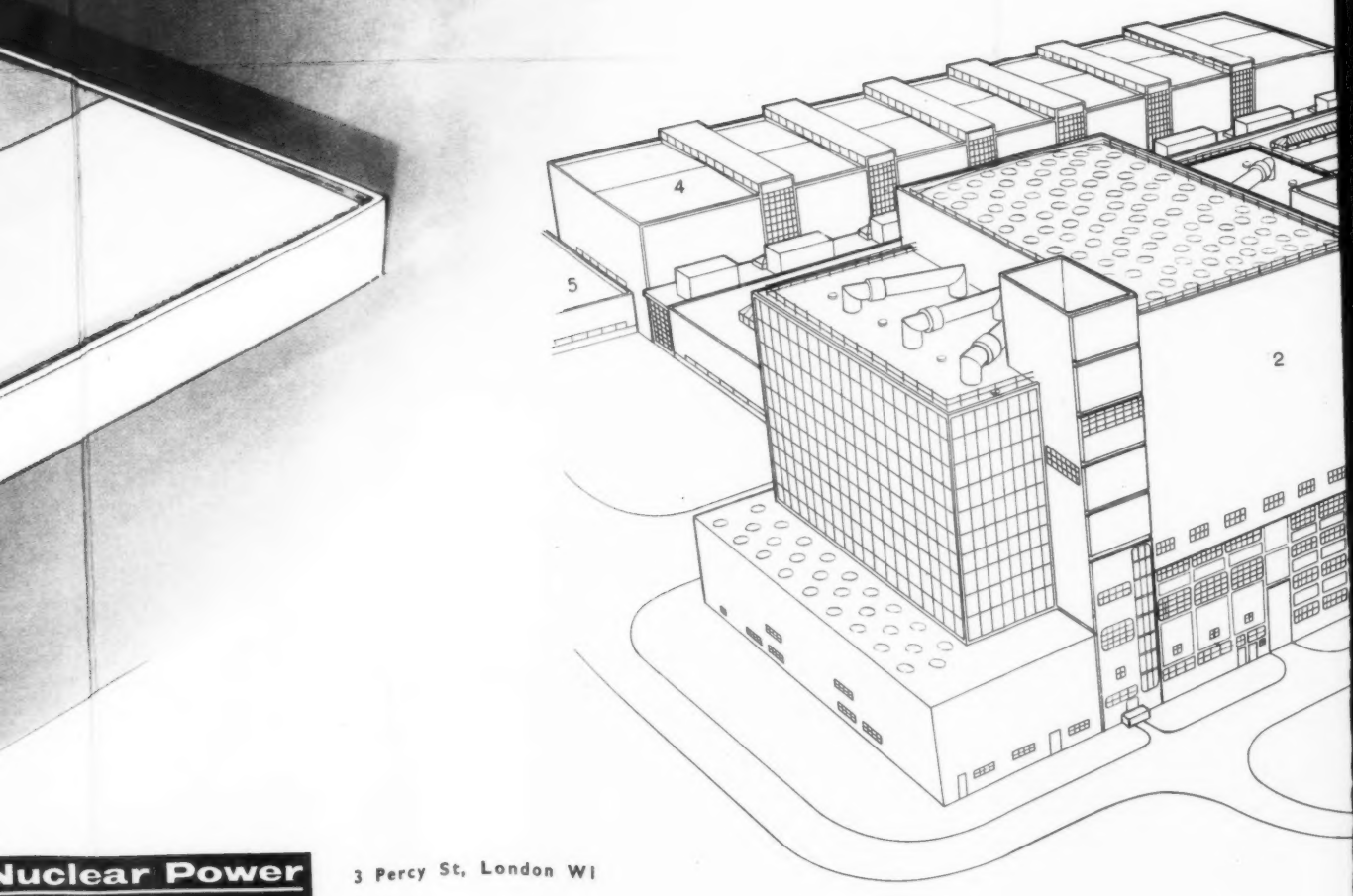
36 Main CO_2 duct
37 Fuel preparation
38 Fuel storage ro
39 Manipulator ro
40 Calorifier and p
41 Hoist well
42 36 in. bypass du
43 Shield cooling fi
44 Main duct gas
45 Lift shaft
46 Shield cooling f
47 Main CO_2 bypas

DESIGNERS A

The Nuclear

Constituent members o

C. A. PARSONS & CO LTD:
A. REYROLLE & CO LTD:
HEAD WRIGHTSON & CO L
WHESSOE LTD:
CLARKE, CHAPMAN & CO L
ALEXANDER FINDLAY & CO
STRACHAN & HENSHAW LT
SIR ROBERT Mc ALPINE & S



Nuclear Power
JOURNAL OF BRITISH NUCLEAR ENGINEERING
3 Percy St, London W1

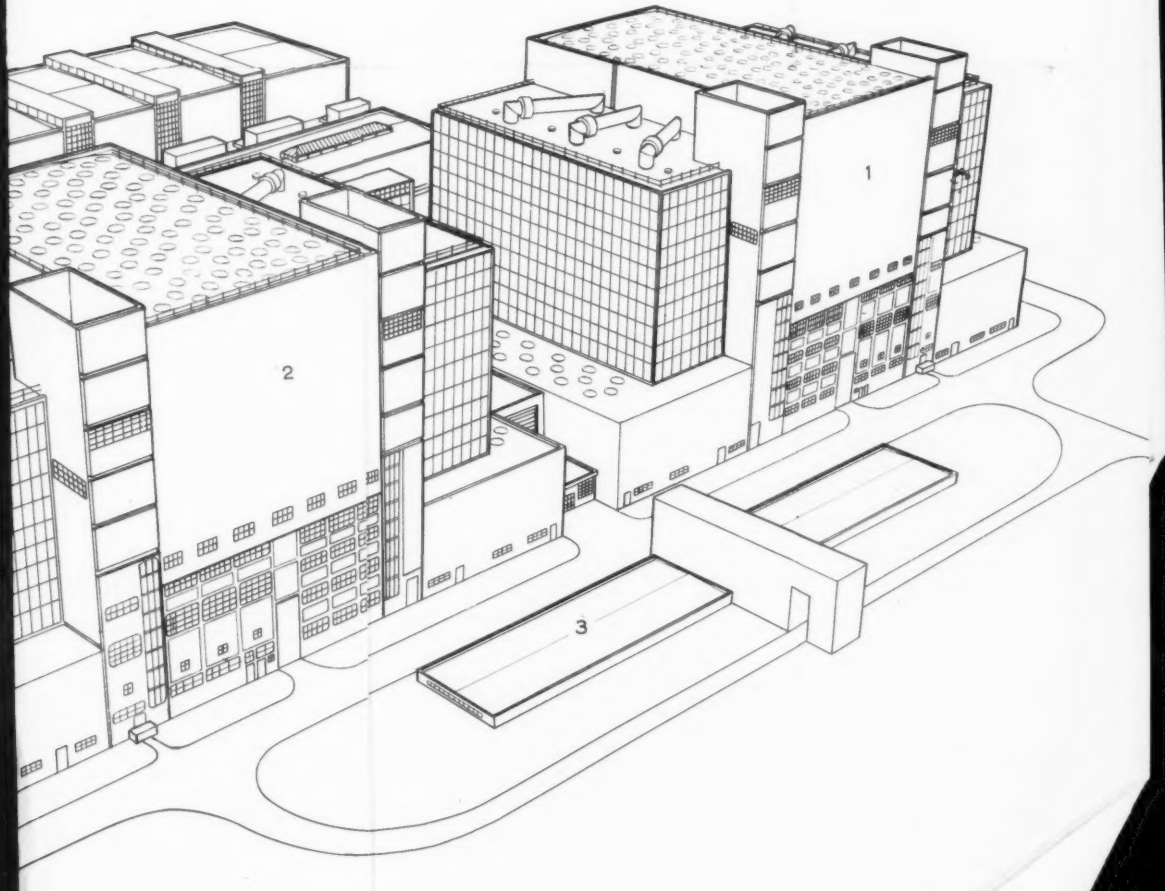
35 Main CO_2 duct, inlet to reactor
36 Main CO_2 duct, outlet to boiler
37 Fuel preparation room
38 Fuel storage rooms
39 Manipulator room
40 Calorifier and pump chamber
41 Hoist well
42 36 in. bypass duct
43 Shield cooling filters
44 Main duct gas valves
45 Lift shaft
46 Shield cooling fans
47 Main CO_2 bypass filters
76 Low pressure boiler circulating pumps
77 Main circulator oil tank
78 Main circulator lubricating and seal oil cooler
79 Main circulator lubricating and seal oil duplex pumps
80 Duct expansion joints
81 Tube access slot
82 Boiler circulating pump boards
83 High pressure boiler circulating pumps

DESIGNERS AND MAIN CONTRACTORS

The Nuclear Power Plant Company Limited

Constituent members of the Company and their share in the Bradwell contract are:

C. A. PARSONS & CO LTD:	Turbines, circulators, ductwork, instrumentation
A. REYROLLE & CO LTD:	Switchgear, control gear
HEAD WRIGHTSON & CO LTD:	Heat exchangers, reactor equipment
WHESSOE LTD:	Reactor pressure vessels
CLARKE, CHAPMAN & CO LTD:	Steam generating plant, cranes and lifting equipment
ALEXANDER FINDLAY & CO LTD:	Structural steelwork, general fabrication
STRACHAN & HENSHAW LTD:	Fuel handling equipment
SIR ROBERT McALPINE & SONS LTD:	Civil engineering, buildings



cated
circula
The
tion r
separa
alterna
Eac
plane
joints.
where
are fi
systen
at 180
10 atn

Safety
An in
provis
plete
that t
The p
natura
even
vice
if all
tion,
flywh
after
two
should
a sim
safety
shoul
and
condi
Eac
vertic
maint
back
lated
speed
opera
systen
gas is
corro

Shiel
Biolo
by a
10 f
below
also
but a
posed
will b
On
comp
expan
ing a
of th
floor
ment
charg
Ins
steel
surfa
over
the r
once
build
down

cated face seal, similar to those used on the Calder Hall circulators.

The circulators are coupled to variable-frequency induction motors fed from two 20·5MW turboalternators in a separate auxiliary turbine hall. A third auxiliary turboalternator is provided as a standby.

Each of the six gas circuits lies entirely in one vertical plane thus eliminating the need for gimbal expansion joints. The ducts are uniformly 5 ft dia, and are fitted wherever required with steel bellows expansion joints. Bends are fitted with aerofoil cascades and the whole ductwork system is on constant-support hangers. Gas enters the core at 180°C and leaves at 390°C, the static pressure being 10 atmospheres, or about 150 psia.

Safety features

An important feature of the gas circulation system is the provision for maintaining cooling in the event of a complete circulator failure. It will be seen from the drawing that the reactor is placed low with respect to the boilers. The purpose of this is to provide the maximum possible natural convection and thereby ensure adequate cooling even if the circulators are out of action. In fact, this device would provide at least 10 pct of full load gas flow if all the circulators were simultaneously tripped. In addition, the inertia of the gas blowers will be increased by a flywheel. This ensures a considerable period of run down after a trip-out and calculations have shown that these two features—natural convection and increased inertia—should ensure that even in the extremely unlikely event of a simultaneous failure of all blowers and instrumentation safety devices the maximum fuel can temperature rise should not exceed 125°C. This would not melt the can and thus the reactor should be inherently safe under all conditions.

Each gas circuit will include isolating valves in both vertical legs so that particular boilers can be shut off for maintenance. Bypass circuits from the circulator outlet side back to the boiler are provided so that with a circuit isolated from the reactor, the blower can be run up to full speed for test. This will be used for bringing a circuit into operation after an outage. There is also a bypass cleanup system by means of which a proportion of the circulating gas is dried, and filtered to remove any entrained dust or corrosion products.

Shielding

Biological shielding for the reactor vessel will be provided by a circular wall of concrete varying from 8 ft 6 in. to 10 ft in thickness. The base of the reactor pit is 48 ft below ground level. The carbon dioxide ductwork and also the air cooling conduits are located outside this shield but a further thickness of 5 ft 6 in. of concrete is interposed between these spaces and the areas to which access will be normally possible.

On top of the pile chamber, the biological shielding is completed by a massive concrete plug fitting on stepped expansion joints into the main concrete mass. The charging and control standpipes terminate on the outer surface of this plug and a further 6·5 ft up a secondary concrete floor covers them over in a number of separate compartments. Access to this sub-floor space can be gained when charging operations are in progress.

Inside, the reactor chamber is lined throughout with thin steel sheet held some 2–3 inches away from the concrete surface to contain a high velocity stream of cooling air over the concrete. The outside of the pressure vessel and the reactor chamber generally are kept cool by a system of once-through ventilation. Air is taken into the reactor building at four points through louvres, filtered and passed down between the primary and secondary biological shields to the basement of the reactor chamber. Here it is distributed through a ring main to a point under the centre of the sphere and to the concrete cooling space. Air also enters the chamber through the standpipe annuli. Extraction from the chamber is through another ring main just below the CO_2 outlet ducts and the warmed air is collected and passed up to filter and fan rooms within the double walls of the upper part of the building. Each of the two fan rooms contains a pair of double-entry centrifugal units discharging straight to atmosphere through low stacks.

Carbon dioxide will be delivered in a liquid form and stored in two tanks in a separate building. When required for make-up it will be evaporated by steam from electrode boilers.

Power generation

Steam at two pressures from the twelve boilers of the two reactors is collected and piped through tunnels to the turbine hall which is about 425 ft long. The main power plant consists of six 52 MW turboalternator sets arranged side by side down the hall. These have high pressure cylinders with two admissions (745 psia, 700°F and 195 psia, 700°F) leading to a double-exhaust low-pressure end. Generation will be by 52 MW, 11·8kV, 3000 rpm hydrogen-cooled alternators. The output will be stepped to 132kW and switched at this voltage to the grid.

Bradwell will really operate as two separate stations, each reactor serving three turbines. There will however be interconnexion, but this is only intended for commissioning and start up. From each reactor group there will be two h.p. mains and two l.p. mains leading to receivers in the turbine house. Twin shell condensers are fitted below each turbine in the usual way and desuperheaters and dump condensers will be fitted, to handle about 20 pct of the total heat output.

Alongside the turbine hall on the reactor side is the building containing the three 20·5MW sets for the blower drives, the main control room and the standby diesel generators.

Cooling water for the turbines will be taken from intake works about $\frac{1}{4}$ mile out in the Blackwater estuary. Water will be taken by twin tunnels from the sea side of a barrier wall to a pumphouse on the sea side of the turbine hall and returned to a point on the land side of the wall to prevent mixing.

Control system

The dual pressure steam cycle makes the control somewhat more complicated than in conventional stations. In normal operation, the h.p. sections are on speed or governor control while the l.p. admission is on pressure control but in fact both h.p. and l.p. sections can be operated on either speed or pressure control. As far as the reactors are concerned it will be the aim to keep temperatures constant and vary the mass flow of coolant by adjustments to the circulator speed. Thus steam demands are made to control coolant flow.

To ensure the maximum safety standards, elaborate protection systems will be used to give an immediate reactor scram following circulator failure, high gas pressure, temperature or power level. All these circuits are in triplicate and depends on at least two-out-of-three giving a positive signal.

As at Calder Hall, there will be a burst slug detection system by means of which it will be possible very quickly to locate a damaged fuel cartridge. Sampling pipes from each fuel channel will run up the control rod standpipes to rotary selector valve adjacent to the pressure vessel, serving a whole group of channels. This will reduce the number of sampling pipes to be taken back to the gas sampling rooms.

NUCLEAR PHYSICS AT BRADWELL

some design aspects

S. E. LEWIS, BEng
Head of Nuclear Division, The Nuclear Power Plant Co Ltd

THE DESIGN of Bradwell was started over two years ago. Whilst having the same 'ingredients' as Calder Hall —graphite moderator, gas cooling, natural uranium—in order however to produce an economic power reactor there were certain changes necessary which from the start introduced some severe design problems. A full description of the nuclear design analysis would completely fill several copies of this journal and so such an article as this can only indicate the overall picture and must attempt to refrain from isolated detail.

Economic utilization studies

The design proceeded in various stages commencing with rough survey calculations to establish some idea of magnitude and to determine the more sensitive parameters. On localization of the field of interest, more comprehensive calculations were performed which embraced the complete station. By this time, the main parameters could be decided upon and much work then followed on design detail. Essentially NPPC and the other three industrial groups were presented with basic lattice constants and associated methods by the Atomic Energy Authority who were, in the early stages, consulted frequently. However, the choice, in the case of the reactor core, for example, of lattice pitch, channel diameter, uranium rod diameter and external core dimensions, was left to each group as, of course, was the power output.

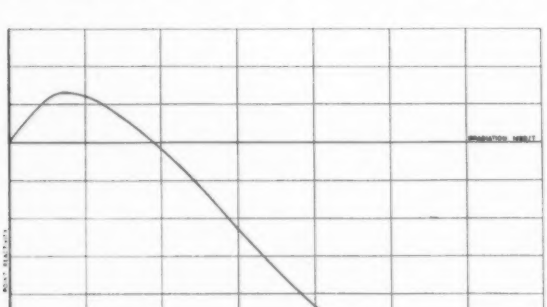


Fig 1 Reactivity v. irradiation for point

It was appreciated at an early stage by NPCC that any optimization requiring calculation of generation costs must necessarily demand reasonable estimates of fuel life and hence studies on the economic utilization of fuel. Such studies on fuel cycles were actively pursued and an early decision was made to operate some form of continuous fuel charge and discharge as compared with the bulk discharge of fuel used up to that time. Thus in all NPPC optimization work attempts were made to estimate fuel life; and 'operating point' as compared with 'zero time' studies were carried out.

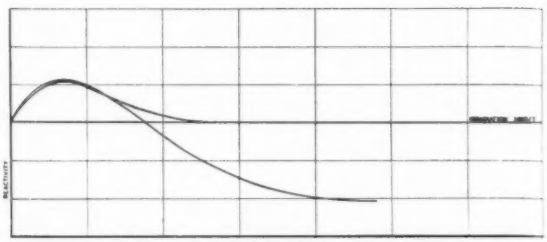


Fig 2 Reactivity v. irradiation for a continuous charge/discharge system—two different rates

Increasing mean irradiation

At any point in the fuel there will be burn-up of U-235 and conversion of U-238 to Pu-239 and the higher isotopes Pu-240 and Pu-241. Thus the absorption cross section of the fuel varies with irradiation and in consequence the reactivity balance is affected. A typical variation is shown in Fig 1. A continuous charge and discharge system involves the achieving of grading of irradiation throughout the reactor such that the positive reactivity associated with short irradiations balances the negative reactivity corresponding to high irradiations. By this means, a higher mean irradiation is achieved, usually 50 pct greater, than if no cycling were employed. In Fig 2 are shown curves of reactivity variation against irradiation for two different constant rates of fuel charge and discharge for a particular system and the smooth approach to equilibrium is noted. In survey work, curves of equilibrium reactivity against equilibrium irradiation are used and Fig 3 shows the curves for three basic systems. They have been derived for a region of constant flux radially and the normal cosine distribution axially where

(i) 'channel' signifies that channels of fuel have been discharged as entities.
(ii) 'point' signifies that any fuel point is assumed to be discharged as required without necessarily disturbing its neighbours.
(iii) 'push-through' implies that fuel is fed axially in a continuous manner.

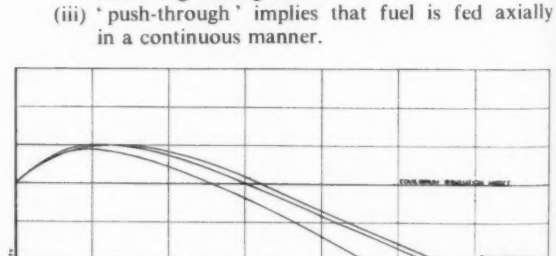


Fig 3 Equilibrium reactivity v. equilibrium irradiation for three basic systems of continuous charge/discharge

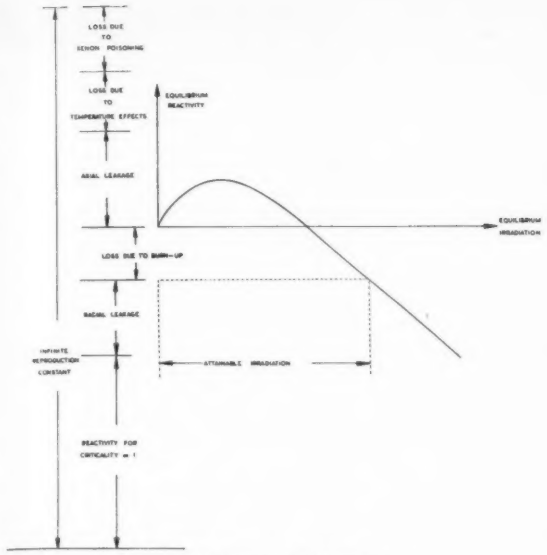


Fig 4 Reactivity balance

Since the rate of burn-up varies as the axial flux in the above cases it has been necessary to obtain an equivalent reactivity change by applying perturbation theory (see Glasstone and Edlund *Elements of Reactor Theory*, Chap. 13). The economic advantage of the push-through system is clear but if fuel charge and discharge takes place from one face alone then excessive fuel handling detracts from the desirability of this system. Innumerable variations on these basic systems are possible but each must be considered in the light of mechanical complication and possible metallurgical limits.

Reactivity losses

Inevitably the removal or movement of fuel will affect the reactivity balance. Referring to Fig 4, the reactivity available outside the lattice is shown schematically, the losses of reactivity being due to xenon poisoning, temperature effects, axial leakage, radial leakage and burn-up. Effectively for a given rating and pile size the first three losses are fixed and so a balance exists between radial leakage and burn-up which is related to attainable irradiation by a curve similar to those on Fig 3. The radial leakage is varied by changes in flattened radius and in consequence the power output varies. Thus a certain heat output could be obtained from a large core with small flattening and high irradiation, i.e. higher capital costs but smaller fuel replacement costs. Alternatively, the same heat output could be obtained from a smaller core with more flattening and consequently poorer irradiation values. An optimization problem is seen to exist.

Fig 5 shows the form of the power output against irradiation variation. Point *A* represents the unflattened pile whereas point *B* corresponds to the maximum flattening attainable and thus the minimum irradiation. This is termed the zero depletion point, i.e. no net burn-up losses of reactivity. Again in choice of lattice pitch, channel and uranium rod diameter another optimization problem arises. Apart from influence of changes in channel and rod diameter on the heat transmission side, it will be appreciated that increased moderator/uranium ratio whilst possibly improving the infinite reproduction constant will worsen conversion factor. Thus the calculation of the effect of changes in these parameters involving the difference of comparable numbers becomes difficult and suspect. It was therefore decided in the case of Bradwell that no change in uranium rod diameter or lattice pitch from those used in Calder Hall could be justified but that the channel diameter should be larger to ease blowing power requirements.

Flux flattening

Whilst similarities exist between methods of control for Bradwell and Calder Hall, a departure has been made in the case of Bradwell by the use of absorbers. In order to achieve the initial flattening some channels on the same lattice as the fuel channels are provided with special absorber elements, the absorption of which permitting of adjustment from time to time. This facility ensures that the reactivity changes that occur with fuel burn-up may be corrected locally thus maintaining the original flux distribution very nearly. This would not be possible if the absorption were provided by the partial insertion of control rods.

Apart from the design aspects of their work, the reactor physicists must predict accurately amongst other things the leakage radiation from the core in order that the shielding physicists may design the complex shields. It is comparatively simple to design and analyse a complete shield. However, since provision must be made for charge and discharge and gas ducts, the consequent apertures introduce many shielding problems. Again the gas itself can be highly radioactive and so a most careful survey must be made of radiation levels around ducts, boilers, blowers and the site generally, continually bearing in mind the need for making available any item of plant for whatever time is required for attendance or maintenance. The

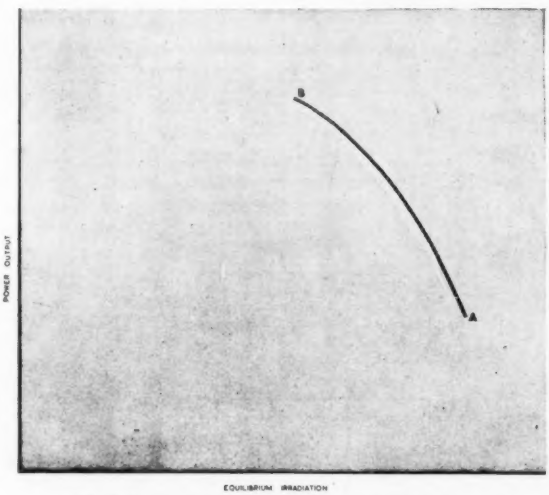


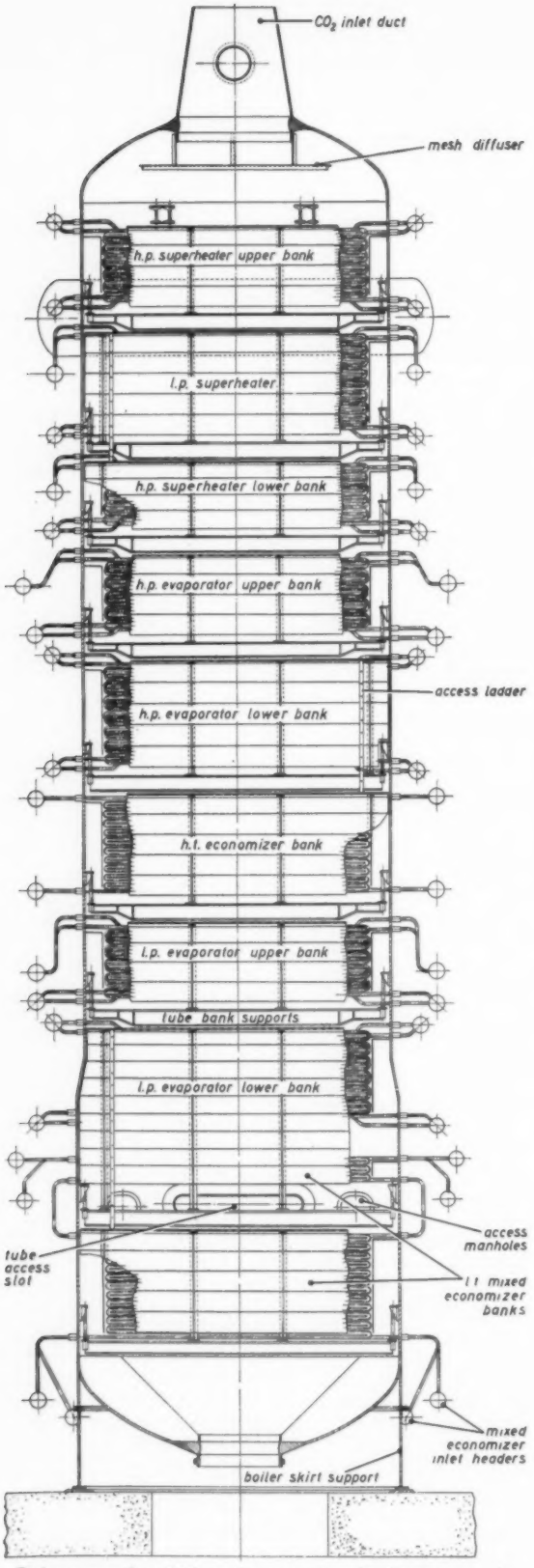
Fig 5 Power output v. equilibrium irradiation

other highly radioactive source leaving the reactor is the fuel which is handled in the charge and discharge machine situated on the pile cap. As well as transporting fuel, it accommodates absorbers, control and charge standpipe assemblies. Problems are again encountered in the transport to and storage in the decay pond prior to removal elsewhere for processing. The aim of the shielding physicist is to prescribe shielding which will provide economically adequate protection for personnel and materials.

Some attempt has been made to describe the rôle of the physicist in the complex problems associated with the design of the Bradwell nuclear power station. However, the success of any design can only come about by the most efficient collaboration between the physicists and the civil, mechanical and electrical engineers.

BRADWELL BO

the design problems and some solutions



Eighty-seven feet high and twenty feet in diameter at the base, the boiler provides high- and low-pressure steam at the same superheat

IN ALL SYSTEMS which are at present available for the practical generation of nuclear power, energy is primarily released in the form of heat. The conversion of heat into electrical power is carried out by well known practical techniques on a theoretical basis supplied by the science of thermodynamics. It could, therefore, be truly said that no new problems are encountered in nuclear power stations in the stages following successful generation of controlled heat in the reactor, and removal of this heat by a circulating coolant. There are, however, some novel aspects and changes of outlook involved. In the transfer of the heat from the reactor coolant to a working fluid for power generation, the problem is not only one of heat transfer-pressure-drop design. An important thermodynamic aspect also exists, and neglect of this aspect may result in uneconomic design of the steam generators or boilers, which represent an important part of the capital cost of gas cooled reactor stations.

Boiler losses

From the thermodynamic viewpoint we can consider the boiler as a means of generating a practically useful working fluid from the heat available in the reactor coolant. In performing this function the boiler is itself a consumer of power in two principal ways: first, in that part of the gas pumping power which can be attributed to the pressure drop occurring in the boiler, and second, in the irreversible process by which the heat is transferred from the coolant to the steam/water stream. The first is already expressed in engineering power units, and it is useful for design optimization to express the irreversible heat transfer loss in the boilers in the same units.

Many thermodynamic routes are available for derivation of this loss. One simple method is to consider first the expression:

$$W = \left(1 - \frac{t}{T}\right)H$$

which gives the maximum work W obtainable from a heat quantity H, in an ideal cycle accepting heat at an absolute temperature T and rejecting it at an absolute temperature t.

In the reactor coolant heat is not available at a constant temperature but at a temperature varying from boiler inlet, T_1, to outlet T_2. Heat rejection is still at constant temperature in the condenser. To cover this case, the first equation is rewritten in differential form; by assuming constant specific heat, H can be expressed as a function of T, and the equation integrated to give the form:

$$W = \left(1 - \frac{t}{T_1 - T_2} \ln \frac{T_1}{T_2}\right)H = eH$$

A treatment of the case where both acceptance and rejection occur at varying temperatures is given in ref. (*1*).

BOILERS

F. CARR, BSc, DIC

Chief Boiler Engineer, The Nuclear Power Plant Co Ltd

Numerical values of e for a constant rejection temperature of 80°F are given in Fig 1.

The single pressure cycle

The use of Fig 1 for determination of heat transfer power loss is illustrated by its application to a single pressure cycle in Table I. The case considered is the generation of steam at 360 psia and a final temperature of 670°F from water at 200°F. The heat source is supplied at an initial temperature of 700°F and leaves the boiler at 400°F.

The boiler is considered in three sections: economizer, evaporator and superheater. Gas temperatures entering and leaving each section are calculated by heat balance, as is the fraction of the total heat transferred which is absorbed in each section.

For each section two values of e are obtained from Fig 1 the first associated with the gas inlet and outlet temperatures, and the second associated with the steam/water inlet and outlet temperatures. Each of these is multiplied by the fraction of heat transferred in the section. The resultant quantities are separately summed for the gas side and for the steam/water side. The first of these sums represents the maximum work obtainable from the heat in the reactor coolant, and the second the maximum work obtainable from the steam. The difference between them represents the heat transfer power loss in the boiler. This

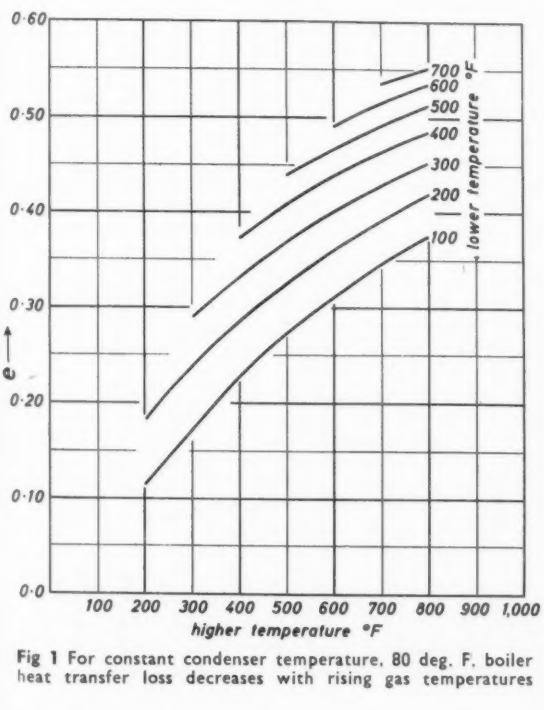
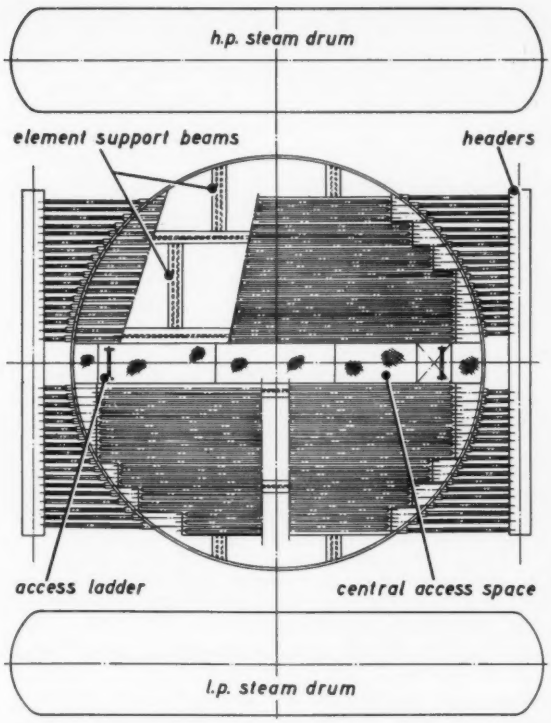


Fig 1 For constant condenser temperature, 80 deg. F, boiler heat transfer loss decreases with rising gas temperatures



Section through boiler shows compact matrix arrangement achieved by tubes of unequal length. Access is also improved

difference is actually a fraction and by multiplying it by the boiler heat load in megawatts a figure is obtained for the theoretical heat transfer power loss in the boiler in megawatts. To put this theoretical figure on the same basis as the pumping power loss, it is multiplied by an efficiency representing pressure losses in lines and governor valves, internal and mechanical efficiency of the turbines, and alternator efficiency. In this case an overall figure of 85 pct is satisfactory.

The approach temperature

In a single pressure cycle such as has been chosen for illustration, the temperature difference between gas and steam/water sides is at a minimum in two places, namely the colder end of the evaporator, and the hotter end of the superheater. In the Table I case, conditions have been chosen to give approximately the same numerical value of temperature difference, 30°F, at these two points. This minimum difference may be termed the approach temperature. By selection of steam temperatures and pressures this approach may be varied; closer approach is characterized by a larger requirement of heat transfer surface and at the same time a reduction in the heat transfer power loss. If the approach temperature be made zero, surface requirements become infinite; however, the transfer loss in this condition does not disappear, but retains a definite value. This residual value may be regarded as an inherent transfer loss resulting from the use of a single pressure cycle with a working fluid which undergoes vaporization during heating. It would clearly be uneconomic to approach this condition in practice, since the pumping loss associated with the very large surface installed would more than counterbalance reductions in the transfer loss obtained thereby. The relationship between pressure drop and heat transfer lies outside the field of the thermodynamic design of the

units, and to maintain the distinction between these two fields, it is described as the thermal design.

The thermal design of boilers for gas-cooled power reactors calls for the use of extended surface on the gas side. The reasons for this are well known and will not be elaborated here. Again for well known reasons the present practice is to have this extended surface on the outside of tubes which contains the steam/water side of the boilers.

Design variables

Accepting these restrictions, and also the fact that all-steel construction is required, there are still many forms of extended surface which could be used. If we restrict the type of surface to annular or helical fins of constant height and thickness, we find that the following variables are still available to the designer: tube diameter, fin height, fin thickness and fin spacing. These four variables refer to the tube only; the tubes must still be arranged in a bundle or matrix, and the spacing between tubes, both horizontal and vertical, and the type of arrangement (staggered or in-line) both materially affect the performance of the matrix as a whole even if the tube is unchanged.

If the whole range of variables indicated above is eliminated by selection of a certain tube and tube arrangement, there are still two characteristics of the matrix itself which can be varied and their influence studied. These two characteristics are the matrix face area and its height.

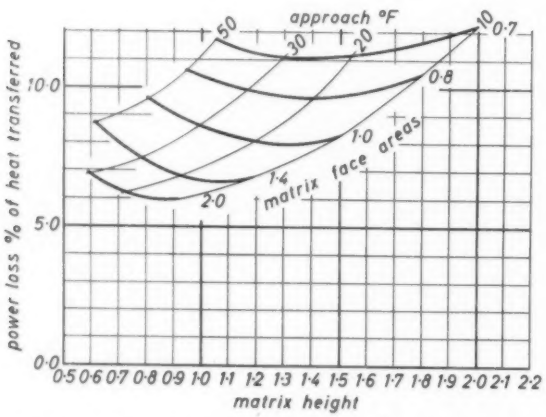


Fig 2 For the single-pressure cycle of Table I, power loss is plotted against matrix height for a range of approach temperatures and matrix face areas

The face area is the area of the space occupied by the matrix, projected on a plane normal to the direction of gas flow before it enters the matrix. The height is the length measured in this same direction.

The influence of these two variables is indicated in Figs 2 and 3. In these, the total power loss, the sum of transfer and pumping losses, is plotted against matrix height in one case and matrix total surface in the other. Variable face area and approach temperature are shown on both graphs. These diagrams represent actual designs worked out for a single pressure cycle having gas inlet and outlet temperatures as in Table I. Although changes in tube or matrix dimensions would affect the curves, the general indications given by these two diagrams are not affected by such changes.

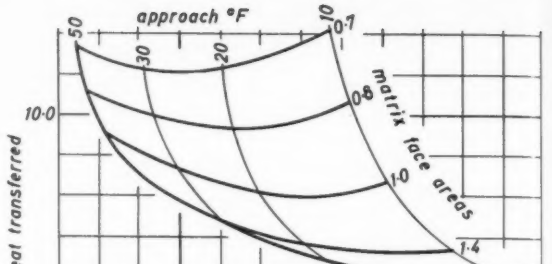


Fig 3 For the same case, power loss against matrix total surface for a range of approach temperatures and matrix face areas

These general indications may be summarized as follows: First, that a large face area is of great value. Second, that the approach temperature for minimum power loss depends on the face area, and is higher for smaller face areas. Although not shown by these graphs, other changes in the matrix are equally powerful in their effect on optimum approach temperature. Third, that for a given face area, it may be harmful to the station output to increase the surface provided by increase of matrix height.

The optimum matrix

Generally speaking, minimum power loss is associated with non-compact matrices of large total volume, tending towards larger face areas and smaller heights. This conclusion is somewhat unfortunate, since the matrix must be contained in a cylindrical pressure vessel, and in such vessels a small diameter to length ratio is economically more favourable. Large face area can, of course, be obtained by increasing the number of boilers associated with

TABLE I Heat transfer power loss in a single-pressure cycle

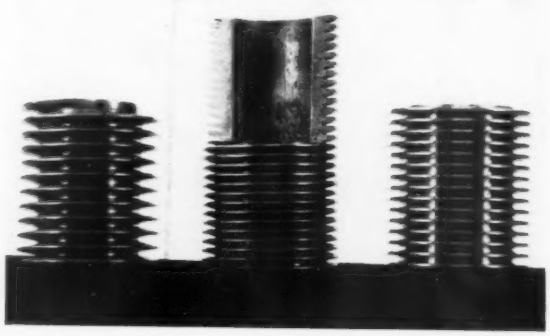
Section	Superheater		Evaporator		Economizer	
1. Gas temps °F in/out	700	665	665	465	465	400
2. ε from Fig 1	·527		·470		·396	
3. Steam/water temps °F out/in	670	434·5	435·5	434·5	435·5	200
4. ε from Fig 1	·466		·396		·300	
5. Fraction of heat transferred in section	·121		·671		·208	
6. (Line 2) × (Line 7)	·0639		·3150		·0824	
7. (Line 4) × (Line 7)	·0565		·2655		·0624	

Sum of Line 6 = heat to work conversion fraction, gas = ·4613
Sum of Line 7 = heat to work conversion fraction, steam = ·3844
Difference = theoretical heat transfer loss fraction = ·0769
Actual loss per 100 MW heat transferred = 100 × ·0769 × ·85
= 6·54 MW power

a single reactor, but such a course would lead to disproportionate increase in capital cost, and might also require increase in the numbers of gas circulators and circuits, again accompanied by disproportionate increase in capital cost.

In these circumstances care must be taken to utilize as fully as possible the space available for face area. The method used in the Calder boilers, namely, accommodation of a matrix of square facial aspect in a cylindrical vessel, leaves room for improvement of vessel utilization. In published information on one subsequent industrial design, the same general method has been used. In the Bradwell design, to obtain the advantages of having six boilers instead of eight per reactor, a matrix having tubes of unequal lengths was used as shown on p. 417. This arrangement provides two clear segmental and one clear central access space, instead of the two clear segmental access spaces provided in Calder. The face area accommodated in a shell of given diameter is increased by over 25 pct by the use of this arrangement as compared to the Calder arrangement, with an improvement in access.

Matrix height is also of importance in its effects on practical requirements of the station. The overall height of the boilers is restricted at a maximum value by architectural considerations and also by the maximum heights available from the erection equipment. Fig 2 shows clearly that height restrictions can prevent the designer from achieving minimum power loss. Here again, the value of face area is apparent, for with larger face areas the minimum in the power loss curve occurs at smaller values of matrix height. The available height of the containing vessel must be utilized as fully as possible for the accommodation of tubes; and the designer must maintain a balance between the conflicting requirements of construction and maintenance which require larger spaces between tube banks, and an efficient and economical design which effects maximum utilization of available vessel height.



Work on integral-finned heat-transfer tubing was carried out by two firms. Left and centre are Head Wrightson tubes: right is ICI 'Integron'

Importance of research

Provision of ample face area must be accompanied by use of a matrix having suitable heat-transfer/pressure-drop performance. The experimental determination of such performance must be based on research of the highest possible quality in view of the economic importance of the boilers.

The research on which the Bradwell boiler design was based was carried out by Head Wrightson & Co Ltd, at Thornaby-on-Tees. In the initial planning of this research it was decided that final designs should only be based on tests simulating as nearly as possible the operating conditions anticipated. For instance, the use of results obtained from an air rig operating at atmospheric pressure is open to objection on two principal counts; first, that in the use of dimensional analysis to obtain a generalized result, and in the use of the result for design purposes, accurate knowledge is required of the transport properties of both air and CO_2. Second, it must be understood that the usual method dimensional analysis, which is to use the Nusselt, Prandtl and Reynolds numbers, is an approximation; other dimensionless groups, some of them affected by pressure, could be influencing the performance by marginal amounts sufficient to have noticeable economic effects. Detection of such effects would not be possible in an air rig. The provision of a pressure CO_2 rig would make such investigation possible, but since such a rig permits close simulation of operating conditions extensive theoretical investigation is not required for design purposes. The rig installed at Thornaby is capable of providing substantial coverage of both present and future operating conditions.

In view of the large number of possible variables, it is not surprising that up to the present time the experimental programme, although extensive, has not lead to any clear cut indications as to the most favourable tube and matrix form. With the limited time that was available for completion of the Bradwell tender, it was necessary to use engineering intuition, rather than a correct scientific approach, to establish forms of extended surface tubes which could be assembled into matrices of good performance.

In the selection of such forms it was also necessary to bear in mind production methods to be used, and the general suitability and reliability of the finished tube.

Development of extended surfaces

Three general methods are available for attachment of extensions to tube outside surface; mechanical bond, welding, and integral forming. The first of these was eliminated, as it was considered inadvisable to devote development effort to what is clearly the poorest engineering solution to the problem. Development work on the second and third methods was carried on simultaneously by Clarke, Chapman, on the welded fins, and by Head Wrightson Machine Co, and ICI Metals on the integral fins. Cold forming of fins from steel tube had not previously been seriously attempted, but rapid progress was achieved. It was found that the type of fin most convenient for cold forming, which was low and closely spaced, was also a good performer from the heat transfer—pressure drop viewpoint. The welding process tends to produce high widely spaced fins, and difficulties are encountered in assembling such tubes into high performance matrices.

The general construction of the boilers follows closely the lines of the original Calder design. Apart from improved utilization of the volume of the containing vessel a few minor changes connected with erection and tube installation have been introduced.

The major part of the shell is 19 ft 0 in. diameter, and a 20 ft 0 in. diameter section is provided at the base. This enlarged section is required to permit insertion of some of the larger tube elements. A flanged slot opening is provided in this enlarged section through which tube elements are passed into the erected shell for installation. The provision of this opening permits gas duct installation and tubing of the boilers to be programmed independently. It also permits maintenance work requiring removal of boiler tube elements to be carried out without disturbance of the ductwork.

Reference

1. *Power savings in process refrigeration*. F. Carr, *Ind. Eng. Chem.*, April 1949, p. 776.

Fig 1 A wide range of 'Integron' mild-steel tubing has already been made—now alloy-steel tubing is under development

Extended Surface

development of integral finned steel pipe for Bradwell and other power stations

THE METALS DIVISION of Imperial Chemical Industries Ltd has recently developed a new *Integron* finning technique to meet the special requirements imposed by the demands of the nuclear engineering industry for completely integral finned tubes made from standard boiler tube material (Fig 1).

To meet the requirements of the Nuclear Power Plant Co. a $2\frac{1}{8}$ in. nominal root diameter tube with 5 fins/in., 5/16 in. high by 1/16 in. mean fin thickness, was developed for Bradwell. Although Marston Excelsior Ltd, a subsidiary of Imperial Chemical Industries Ltd, has done a series of heat transfer tests on *Integron* and published information for design purposes which has successfully been applied to the larger sizes of steel finned tube, no first-hand information is available on the behaviour of the Bradwell type of tubing working in carbon dioxide. Extensive heat transfer tests have been carried out, however, on this tubing in a special carbon dioxide rig at Head Wrightson & Co Ltd, Thornaby-on-Tees, and approximately 1,000,000 ft.—200 miles—will be used in the boilers at Bradwell.

Mild steel used

In the first series of nuclear power stations the service conditions in the boilers are modest when compared with modern steam raising plant employing conventional tubes. As a result alloy steel tubes are not required and mild steel tubes are completely adequate. Because of this, effort has been concentrated on developing mild steel *Integron* but similar attention is now being given to making *Integron* from seamless $\frac{1}{2}$ pct molybdenum and 1 pct chromium molybdenum tubes conforming to BS1652 and BS1653. These materials may well be needed to withstand the more arduous conditions that are likely to obtain in the hotter zones of future power station boilers.

The completely integral form of the tubing (Fig 2)—the fins are raised from the tube wall by a cold working operation—offers many unique advantages compared with other types of extended surface tubing. There is no possibility of either mechanical or heat transfer bond problems arising between tube and fins, neither is there any danger of bond failure due to vibration, the fins actually increasing the strength of the tube.

Stock material for finning

The *Integron* process on mild steel tubes is carried out cold and has the effect of cold working the whole of the tube. However, though the fins are relatively heavily cold worked, plastic deformation of the bulk of the residual wall is only slight. This is illustrated in Fig 3 which shows the microstructure in typical transverse sections through the bore of the tube before and after finning. The finning operation clearly does not distort the structure in this region of the wall, and in fact, the mechanical properties remain suitable to meet service conditions. However, because the tubes are used in the cold worked condition, it is necessary to guard against the danger of undesirable strain ageing effects. For this reason, fully aluminium-killed fine grain mild steel has been adopted for those applications where, according to British Standard, the service conditions are such that conventional tubes could be made in the slightly cheaper rimming steels.

Following a number of controlled trials and thorough metallurgical examination by the various nuclear energy consortia, the Central Electricity Authority, Lloyd's Register of Shipping, The United Kingdom Atomic Energy Authority and ICI Metals Division, it has been established that, for use in nuclear power station heat exchangers, the

Fig 2 Longitudinal section shows fin profiles of Bradwell boiler tubing (unetched × 6)

stock can be any of the recognized standard boiler tubes, for example hot rolled (BS512), cold drawn (BS494), electric resistance welded (BS1654) or alloy steel tubes such as BS1652 and BS1653. Whichever specification is used for the purchase of stock tubing will also be used for inspection purposes for the finished *Integron* tube.

For Bradwell the stock tubes are $2\frac{1}{8}$ in. o.d. by $\frac{1}{2}$ in. wall thickness hot rolled quality tubes which comply with BSS512 and are supplied by Stewarts & Lloyds Ltd, Glasgow, full inspection being carried out on both the stock and finished tubes by Lloyd's Register of Shipping, Land Division.

Boiler Tubing

F. HOWARTH, AMIMechE, AMIProdE

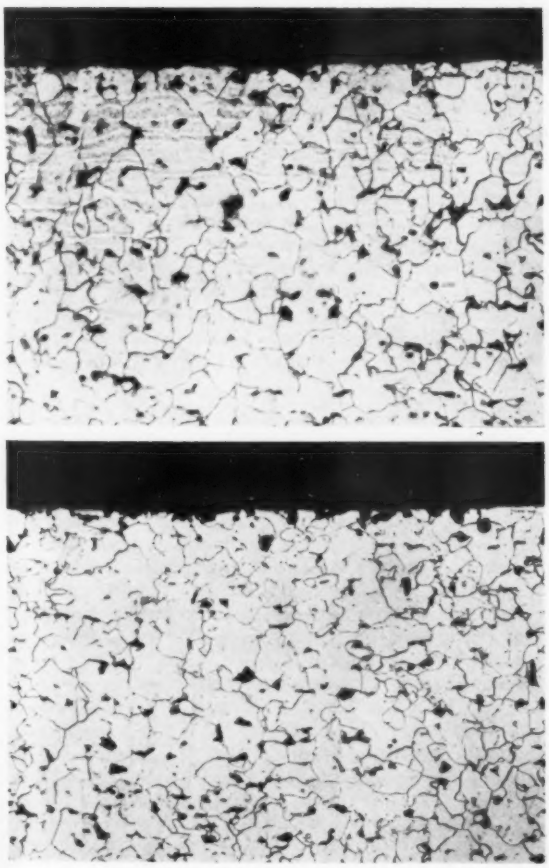
Development Officer, Metals Division, Imperial Chemical Industries Ltd

Rotary cold extrusion process

The Metals Division of ICI has been making *Integron* integral finned tubing since 1938 in copper and aluminium under licence to patents held by the Wolverine Tube Division of Calumet and Hecla Inc, USA. This type of tubing has a helical fin formed from one piece of metal, the fins being squeezed from the tube wall by a rotary cold extrusion process. The new finning technique developed by ICI makes a similar tube except that the fins are of annular formation resembling the pattern obtained by placing a series of independent discs over a tube. All the features of the 'one-piece' formation have been maintained.

Metals Division has manufactured all the steel finning machines, special provision being made to enable them to cope with the wide range of tube diameters and fin spacings and to allow for improvements in fin heights and tube sizes which will be available for future stations. A comprehensive tool manufacturing unit has also been created to form the profile on the tool blanks which are bought out in the otherwise ground and finished condition. The forming tools have been specially designed to produce fins with a smooth profile and which blend into the tube wall with a generous radius offering good anti-fouling properties. Particular care is taken to avoid folds or laps in the surface which might have stress raising effects. Fig 2 shows the finned profile typical of the tubes being incorporated in the heat exchangers of Bradwell Power Station and Fig 4 shows the flow lines in the fins and illustrates the freedom from irregularities that is consistently maintained.

Fig 3 The fin-forming process leaves the metal structure undistorted near the wall. Transverse section through bore shows micro-structure before (above) and after (below) (both etched in Nital × 150)



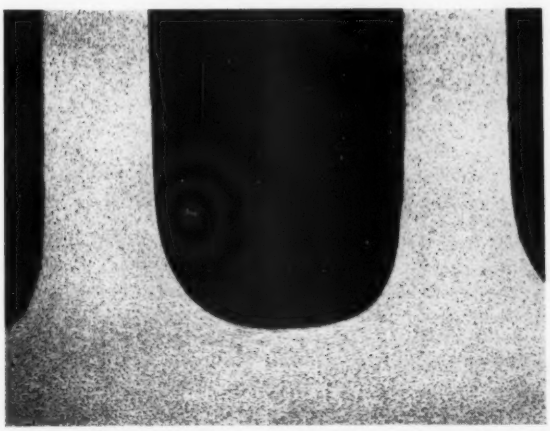


Fig 4 Longitudinal section of Bradwell tubes shows even flow lines at fin root (etched in Nital × 10·5)

Fins formed in one pass

Tubes are received by road or rail and unloaded by an auxiliary overhead crane which serves a battery of finning machines and the special finishing plant. Each tube is swage pointed at one end and then loaded in batches on the finning machines, where they are selected by hand and fed, by means of a special type of pinch roll which also spins the tubes, into the finning head (Fig 5). The fin is formed by three rolls equi-spaced at 120° round the tube. Each roll consists of a number of formers of gradually increasing diameter and changing profile. The first former makes a small groove which is rolled deeper as the tube progresses through the rolls. At the same time, the thick stubby fin, which is trapped between the first two formers, is gradually squeezed out to form a high fin. The tube is automatically fed through the forming rolls and the fins are cold extruded in one pass through the machine.

The finned tubes are then lifted in bundles by the overhead crane and deposited onto a roller conveyor unit feeding a Noble and Lund circular end cutting saw where they are sawn to finished length (Fig 6) then passed on to a hydraulic test unit for pressure testing at 1775 psi, any bent tubes being shunted to a straightening press for rectification. They finally move along the conveyor to an inspection station where each tube is minutely examined

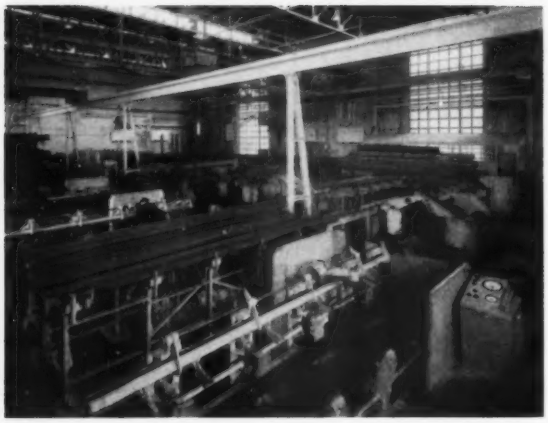


Fig 5 Part of the battery of ' Integron ' finning machines at the ICI works. Tubes are finished in one pass

by a team of inspectors from Lloyd's Register of Shipping, NPPC and ICI.

Size specification

A novel feature of the size specification is that each dimension is based on a minimum figure with an overriding clause for a calculated average outside surface area per foot run.

The designer is therefore assured that each bundle of tubes will have at least the same average area as the tubes used for initial heat-transfer test purposes and on which the heat exchanger design has been based.

A wide range of tubes with root diameters varying from $\frac{7}{8}$ to $2\frac{1}{8}$ in., fin height from 5/16 to $\frac{1}{2}$ in., mean thickness ·06 in. to ·04 in. in both 5 and 7 fins per inch have already been processed, and at this stage it is regarded as being too early both in the development of the finning technique and nuclear heat-exchanger design to finalize on a range of sizes.

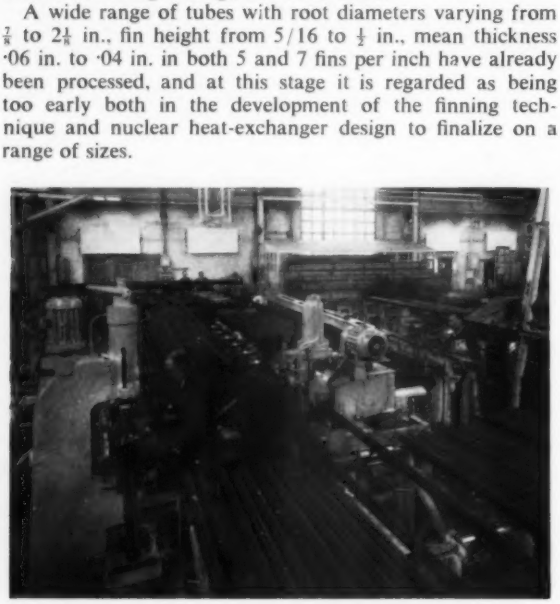


Fig 6 Completed tubes are sawn to length and straightened. All are pressure-tested in rig to the right

Scope for further developments

Theoretically it is possible to fin any size of tube with any number of fins per inch and with fins of varying shape and thickness, fin height being limited only by the plastic properties of the material involved. These limits have not been reached with the present series of finned tubes, and a large scale development programme is now in progress.

Bradwell

TURBO-AL

auxiliary turbine sets and gas circulators

THE POWER PLANT, which will be constructed by Parsons, comprises six main turbo-generators each of 52 MW output and three auxiliary turbo-generators. They are also supplying the condensing plant and dump condensers together with the main gas circulators, gas ducting and valves, the charge tube assemblies and control rod assemblies, fission product detection compressors and the instrumentation including the start-up equipment. All the electrical transformers will also be supplied by Parsons.

Main turbo-generators

The turbines for the main sets, comprise a single-flow h.p. unit solidly coupled to a double-flow l.p. unit. The blading is of the all-reaction type, that in the initial stages being of the well known ' end-tightened ' type, while towards the exhaust, radial clearance blading is used. The blading material is of low-carbon stainless steel. Steam is admitted to each turbine at two different pressures so that there are two separate steam chests to each set, and these are arranged on opposite sides of the machine. Each chest contains its own emergency stop valve and governor valve for controlling the admission of the h.p. and l.p. steam respectively, but as it must be possible to test valves whilst the machine remains in operation they are duplicated within their own steam chest.

The turbines exhaust into single condensers arranged for two-flow operation on the water side, with water boxes of the divided type. The divided water boxes both at inlet and outlet are connected by manually operated butterfly valves. This enables approximately full flow of water to be maintained through a condenser when one culvert is out of action. Two full capacity three-stage air ejectors are provided with two duplicate full capacity motor-driven extraction pumps.

A single dump condenser is provided for each reactor which is capable of handling up to 20 per cent of the heat output. The condenser is fitted with main and secondary desuperheating equipment.

Provision is made on each main turbine for steam extraction at two pressure stages for low pressure bled steam feed water heating, and for this purpose there are two low-pressure heaters and a drain cooler. The capacity of the heaters is adequate to include the additional condensate obtained from the auxiliary turbines, arrangements being made to give an even distribution of feed between machines.

The main generators are hydrogen-cooled and rated at 52 MW, 11·8 kV, 0·8 P.F. at 15 psig hydrogen pressure.

Auxiliary turbo-generators

The auxiliary turbo-generators are rated at 20·25 MW at 3318 rpm. The machines are of the single cylinder all-reaction design and will be supplied with steam from the low pressure supply. A single steam chest mounted along-

ALTERNATORS

C. A. PARSONS & CO LTD

side each turbine contains an emergency valve, governor valve and overload valve to control the steam admission. Each turbine exhausts into its own condenser which is fitted with two full capacity two stage air ejectors and two full capacity motor driven extraction pumps.

Each auxiliary generator is designed to supply the power required for the six induction-motor-driven gas circulators for each reactor, and since the speed of the gas circulators and hence that of the generators, is variable, there are several unusual design features incorporated in the design.

The generator is air-cooled, the air being circulated through a closed circuit by means of fans mounted on the rotor shaft. It is designed to operate over a frequency range of 55·3 to 10 cycles per sec.

Under normal conditions of operation, the motors will be energized and run up from a low speed, but the generator is designed so that when supplying five of the motors at normal speed the sixth motor may be switched on direct without excessive voltage drop of the generator.

A main exciter and a constant voltage pilot exciter are provided. These are driven by two motors in tandem, the complete exciter unit being in one line and erected on a common bedplate. The power supplies to the two motors are obtained from separate sources, and in the event of a supply failure at one motor the remaining supply and motor is capable of driving the exciter for a period of two hours, during which time the continuous maximum rating of the generator can be maintained.

Gas circulators

As has already been made clear in papers read before the British Nuclear Energy Conference*, the selection of centrifugal circulators for the Calder project was dictated by the large speed turn-down ratio and the use of Ward Leonard control with d.c. driving motors. The difficulties associated with gas leakage in this type of installation led the designers for the Bradwell Station to consider the building of centrifugal blowers inside the boiler shells thereby obviating the need for horizontal joints and the use of axially driven circulators.

The conditions in the circuit readily allow of the use of a single-stage axial-flow circulator and after considerable work had been done on alternatives, this type was selected as giving a straightforward and reliable solution.

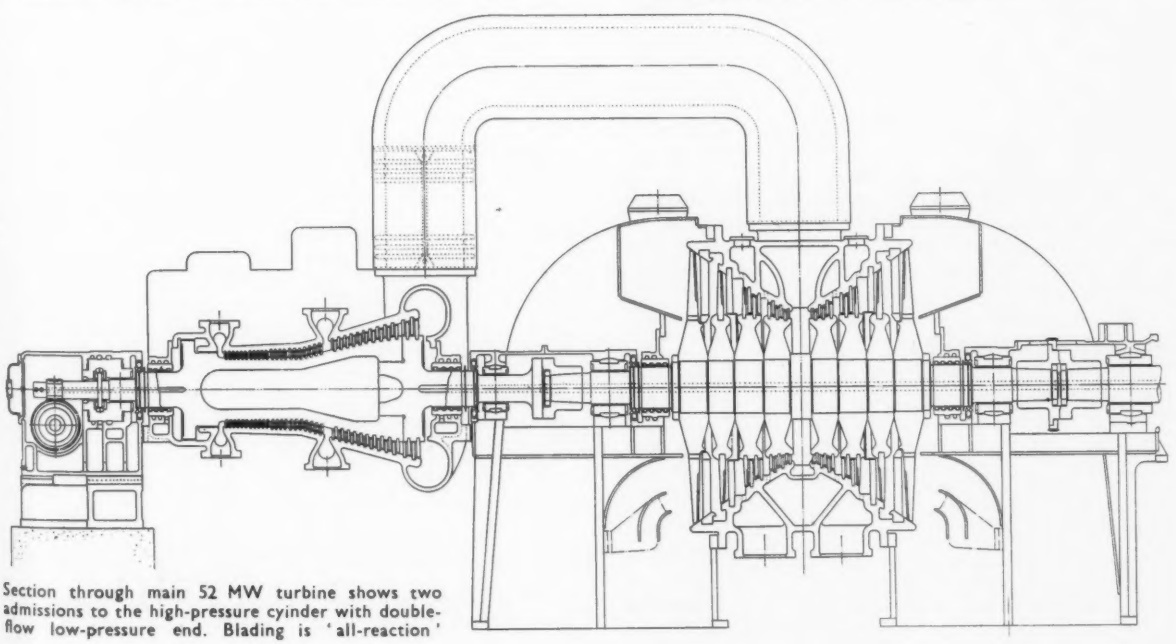
The use of a pressure shell directly connected to the boilers, which readily allows of low loss inlet and outlet conditions and at the same time permits of a readily retractable bladed unit with only a single circumferential joint to the pressure shell, has many advantages and has been found on tests already carried out on a full-scale circulator to show these to the full.

An oil/gas seal, similar to that used in the Calder project, has been used in the design of the Bradwell circulators and tests on the complete unit on a closed circuit rig, have been going on since the beginning of the present year.

The auxiliary turbo-generators feed squirrel cage motors direct-coupled to the circulators, which normally run at 3000 rpm for full load conditions. This system provides a positive and reliable synchronous link to all six circulators connected to the reactor system.

Pony motors capable of taking the circulators up to 20 pct normal speed are fitted, and these operate on the driving shaft through an SSS type clutch which automatically engages or disengages when the speed of the circulators reaches the 20 pct figure. All the plant has been designed for a 10 pct overload.

* "Design of important plant items" by A. T. Bowden, BSc(Eng), PhD, MIMechE, and G. H. Martin, MIMechE, AMIEE.



Section through main 52 MW turbine shows two admissions to the high-pressure cyinder with double-flow low-pressure end. Blading is 'all-reaction'

LAYOUT AND SERVICES

some Bradwell considerations

T. ANDREWS, MSc(Tech), AMICE

Design Coordinating Engineer, The Nuclear Power Plant Co Ltd

CERTAIN CHARACTERISTICS OF nuclear stations—for example, the size of the power sources, the problem of shielding, the absence of coal handling gear—require that their layout be tackled in a radical manner, despite the fact that a considerable proportion of the plant involved is conventional type. It is, therefore, not surprising that the layout of Bradwell differs in several particulars from that of conventional power stations. Its features are:

(a) The reactor buildings
(b) The turbine house and associated buildings
(c) The fuel storage pond
(d) The pumphouse and circulating water works
(e) The ancillary, service and welfare buildings

Of these, the first two are the most important and contain the major items of plant. By their size and function, they largely determine the siting of the others.

Constructional facilities important factor

Of considerable importance, however, are the circulating water works, which, since they connect to a predetermined point (the barrier wall), affect the position and alignment of the station buildings. The locations of the access road and the switchyard are further factors. Finally, allowance has to be made for temporary works and for site equipment, upon which speed of construction depends. With a nuclear station, in which vessel fabrication, lifting and erection present problems of unusual magnitude, the importance of such facilities cannot be over-emphasized.

The site covers approximately 140 acres and, being low-lying, is protected by a sea wall which forms its northern boundary. The whole of the operational area will be raised above floor level by earth fill, the extent of which determines in part the level of the turbine house.

The general location of the turbine and reactor buildings was selected so as to provide satisfactory foundation conditions and at the same time produce an economic turbine house level. Consideration of these factors resulted in the northern boundary of the principal buildings being placed some 400 feet from the sea wall.

Nuclear and conventional areas

The alignment of the turbine house was chosen to give a short direct route for the circulating water culverts. The relative positions of reactor buildings and turbine house were chosen to allow ample room for constructional plant and equipment; in addition, the transverse centre lines of these groups of buildings were made coincident, with the object of providing simple and economic routes for the connecting services.

It is desirable to separate the operational areas of nuclear and conventional plant. For this reason, the fuel storage pond was sited at the side of the reactor buildings remote from the turbine house. This face of the reactor buildings is consequently taken up for the most part by equipment concerned with fuel handling and preparation.

Probem of control room

Of particular interest is the position of the control room which, although part of the turbine house block, deserves separate mention. It was thought desirable to locate the control room and its associated offices as nearly as possible in a central position to provide ease and directness of access to all main operational areas. Consideration was given to its housing in a separate block between the reactors and the turbine house, but its siting in this position would have either lengthened the routes of the services and increased the area of the station, or greatly reduced the area available for constructional plant. Incorporation of the control room in the reactor buildings would have interfered with the free use of the Goliath crane—the principal erection tool—or have caused programming difficulties. For these reasons, it was decided to site the control room on the station transverse centre line and contiguous with the turbine house.

The space left between the turbine house and the sea wall provides ample area for the construction of the pumphouse, on which work could proceed in the dry. Alternative schemes, involving the building of the pumphouse on the seaward side of the sea wall, were examined, but were rejected for economic reasons. The pumphouse was positioned as closely to the turbine hall as construction requirements allowed in order to reduce the length of pressure culvert and service connexions. Its position, together with the layout of the turbine house culverts, referred to later, conforms to the arrangement of the barrier wall intakes and outfalls specified by the Authority; no culvert crossings are involved and excavation for these works is kept to a minimum.

Controlling access to reactors

Ancillary buildings (e.g. the canteen and welfare blocks, workshops and stores) are sited near to the southern boundary of the station since it is from this direction that the access road approaches. Location of the workshops and stores immediately adjacent to the turbine house provide convenience of access for maintenance staff; a corridor separating the stores and workshop continues under covered walkways and links the welfare and canteen blocks with the turbine house.

Sufficient space is left between the inner blower houses of the reactor buildings for boiler erection. This area will later be occupied by the main change rooms through which all persons entering the reactors will pass. In this position, it clearly conforms with the pattern of traffic to and from the reactors.

To the east of the reactor buildings, and symmetrically disposed in respect to them, is the site for the fuel cool-

ing pond. The area between the pond and the reactors is enclosed by a fence through which access will not normally be allowed. Such an arrangement is essential to the proper functioning of the change rooms, by which the dispersal of active material is prevented. Two further restricted areas will be provided, one for plant for active effluent treatment and the other for the disposal of active solid waste.

The steam and feed piping and the cables between the reactors and turbine house are accommodated in tunnels. This arrangement contributes to the appearance of the station and also enables maximum use to be made, during the construction period, of the area between the reactors and turbine house.

Reactor block analysed

Each reactor building is composed of ten principal parts. They are:

(1) The space enclosing the pressure vessel, and bounded by the biological shield.

(2) The space above the vessel (the charge machine hall) occupied by the charging mechanism and its auxiliaries.

(3) Two tall, narrow enclosures adjacent to (1) and (2) and positioned on either side of them, occupied principally by the vertical portions of the gas ducting.

(4) Two enclosures, adjacent to the ducting shafts, in which are located the boilers, there being three units in each house.

(5) The blower houses, located in part below each boiler house and occupied by the gas blowers and auxiliaries, and by gas cleaning plant.

(6) A structure, abutting the biological shield to the west, and facing the turbine hall, in which control equipment, switchgear, flux measuring and fission product detection gear are located.

(7) A structure similar to (6), adjoining the biological shield to the east or cooling pond side, providing accommodation mainly for fuel handling and preparation. One end of this structure, where it overlaps the gas ducting shafts, is occupied by trunking for the shield cooling system.

The relation of the vessel and charge machine hall follows naturally from the decision to employ vertical charge and discharge arrangements (a system common to all British power reactors) and top charge and discharge. The positions of the boilers are such as to reduce to a minimum the horizontal expansion of the gas ducting; their disposition radially with respect to the reactor vessel makes possible the use of co-planar ducting arrangements which eliminate troublesome torsional moments on ducts, vessel, and boiler shells.

Reducing overall height

Positioning of the blower houses substantially below the boilers follows naturally from the choice of horizontal spindle axial machines for gas circulation.

To provide good natural circulation in the gas circuit the presure vessel was located partly below ground level. The height of the reactor structure as a whole was thereby reduced—a not unimportant factor from the amenity point of view; access to the pile cap was eased. The overall height of the reactor structure was further reduced by the employment of high velocity nozzles, in lieu of stacks, for cooling air discharge.

The function of the 'control' and 'fuel' face structures determined their location.

The length of the fuel cooling pond was fixed partly by the position of the fuel discharge shafts within the reactor buildings, and partly by the storage capacity of the pond. A symmetrical and economic arrangement was the result.

Factors in turbine house layout

Early in the design study, it was decided to use six turboalternators of robust stiff design, similar to well-proved CEA standard machines. A longitudinal arrangement of turbines would have entailed the construction of a turbine house of inconvenient length; either the principal service routes would have been long, or the distance between the reactor buildings would have been substantially increased, as compared to the layout finally adopted. A transverse turbine arrangement was therefore decided upon.

The construction programme—involving the commissioning of six 52 MW turboalternators within 24 months—made essential the provision of two cranes and two loading bays. The size of these bays, and the spacing of the turbines, determined the length of the structure. Particular attention was paid, when fixing the machine spacing, to the need for component 'parking areas' during erection.

The economic turbine house basement level was found to be 19·5 feet below finished ground level; the operating floor, as a result, is 10·5 feet above ground level.

Examination of possible means of blower drive led to the selection of the turboelectric system, employing variable frequency alternators electrically coupled to induction blower motors. The location of these machines—in a house adjoining the main turbine hall—was chosen because the supply of cooling water to them was convenient and because the only other possible site (adjacent to the reactor buildings) would have increased the length of the reactor block disproportionately. It was found possible to make the basement levels of the two turbine houses coincide, the operating floor in the smaller house being conveniently arranged at ground level. The loading bay of this house is a continuation of the bay at the north end of the main hall. The auxiliary turbine house thus occupies a position, adjoining the control room, at the north-east corner of the turbine house block.

The basements of both turbine houses are extended beneath the control room, providing a centrally disposed space for auxiliary plant such as compressors and automatic fire equipment. The main turbine hall basement is extended also beneath the loading bays, providing space for two dump condensers, one per reactor. To the south of the control room lies a structure of moderate height, housing batteries, diesel generators and water treatment plant, in that order.

Such a layout provides easy access to the standby plant from the control room, whilst the control room is insulated, as it were, from the diesel generators, by the battery room. The water treatment plant is located at the end of the turbine house block nearest to the town's water supply.

Electrical layout

The position of the switching area requires the electrical ends of the main turbines and the transformer bays to be at the west side of the turbine house; the steam ends of the machines then naturally face the reactor buildings. An orderly separation of the steam and feed and principal electrical routes results.

Between the auxiliary structures and the main turbine hall is an annexe accommodating: at basement level—the feed pumps and steam receivers; at operating floor level—the pipe loops, and; at roof level—the surge and general service tanks.

It may be claimed that Bradwell is both compact and logical in its layout design and lends itself to a coherent architectural treatment.

BOILERMAKING FOR BRADWELL

Unorthodox transport arrangements

HEAD WRIGHTSON & CO LTD

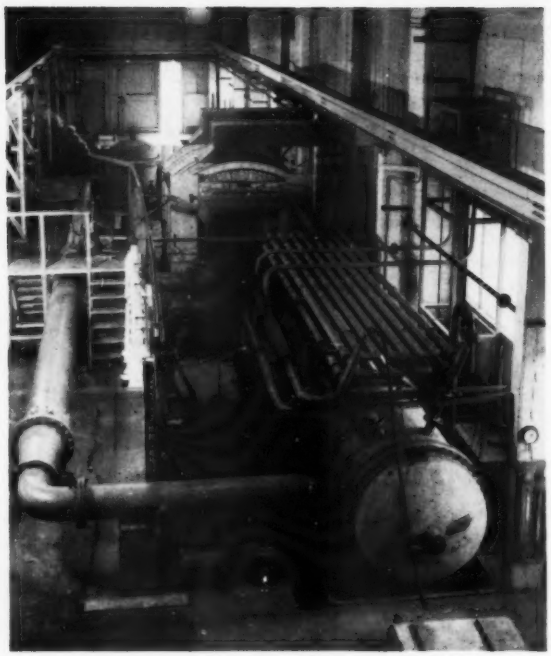
SINCE early 1956, when work first commenced at Head Wrightson on the study and preliminary design of nuclear power stations, a qualified staff of 60 has been built up. Under a General Manager, this Nuclear Power Division carries out in detail the responsibilities of Head Wrightson & Co Ltd, as a member of the Nuclear Power Plant Company Ltd consortium, for the supply of steam-raising and reactor equipment and services. These activities are augmented by a close liaison with the Head Wrightson Research and Development Department, a large part of whose extensive programme is devoted to the nuclear field.

At Bradwell, Head Wrightson are supplying the twelve boilers; the shield cooling equipment; the support plates, bearings, restraints and charge pans for the graphite core; the CO_2 storage plant; the gas blowdown system; the CO_2 pile cap piping; the CO_2 interconnecting piping; the pond cooling system and the effluent treatment plant. In addition, the provision and operation of the graphite site storage facilities, and the laying of the graphite core in clean conditions within the reactor will be the Company's responsibility.

Boilers to be floated

Delivery schedules are being maintained in the manufacture of the boiler shells at the Thornaby-on-Tees works, but the preliminary work necessary to achieve this has taken many months and raised many problems. A detailed fabrication programme was first worked out involving the many operations of sizing, rolling, drilling and preparing the $1^{9}/_{16}$-in. thick plate for welding. Special arrangements were made for normalizing, and for an extremely rigid inspection of the mill material, using the ultrasonic flaw detection. Special welding manipulators were obtained to handle the vessels during fabrication, and additional shop capacity built to accommodate four boilers simultaneously in various stages of manufacture. New and advanced welding procedures were adopted, and a system of inspection devised to cover every stage of fabrication including the final X-ray examination of the welds. The supply of steel plates and other raw materials, has called for close collaboration with suppliers to ensure the necessary flow into the works.

Transporting the 90 ft long by 20 ft dia. boiler shells from Thornaby to Bradwell, a distance of some 250 miles presents a big problem. Road or rail presented too many difficulties, so it was decided to tow the vessels by sea. A launching slipway has been built into the river Tees and each shell will be launched tail first into the water. In order to make each boiler seaworthy, some 1,300 apertures have to be sealed, and timber fenders fitted to prevent damage. Given reasonable weather conditions, each journey should take about $2\frac{1}{2}$ days, and on arrival at Bradwell Creek, the shells will be loaded on to a special low loading vehicle and positioned under the Goliath crane. As at Thornaby, a slipway has been constructed at Bradwell to facilitate landing which must be carefully timed to coincide with the tides.



At the Thornaby works a closed circuit test rig is used to study, under actual operating conditions, heat transfer properties of boiler tubing

The Erection Section will direct and supervise a large labour force at Bradwell, many of whom will be highly skilled craftsmen. Detailed plans for the stage by stage erection in collaboration with other member companies have been completed. The last boiler is due to be completed in July 1960.

Heat transfer research

A considerable part of the Head Wrightson Research and Development Department's activities is devoted to nuclear matters. Research work has been carried out on heat transfer between CO_2 and the *Integron* boiler tubes, using a closed circuit test rig designed to operate under actual operating pressure and temperature conditions. In this, the centrifugal circulating fan is enclosed within a vessel containing gas at the static pressure in the circuit, thereby obviating the use of a multi-stage compressor. Heat is supplied by an oil-fired furnace to raise the gas to the appropriate temperature. For quick comparative measurement of flow and heat transfer on various components, an atmospheric pressure 'sorting' rig is being installed. On the steam side two rigs are being built for investigating pressure drops, flow stability and heat transfer in the boiler tubes, and equipment is also being set up for determining physical properties of fluids, e.g. viscosity, thermal conductivity. Support problems of the graphite structure have been dealt with by experimental stress analysis.

The Metallurgical Section, in addition to dealing with all the immediate problems of manufacture, is undertaking development of low-alloy high-tensile weldable steels in order to meet the exacting requirements of the future.

Shell's cobalt-60 facility reports radiation-resistant oils

SPECIAL LUBRICANTS FOR BRADWELL

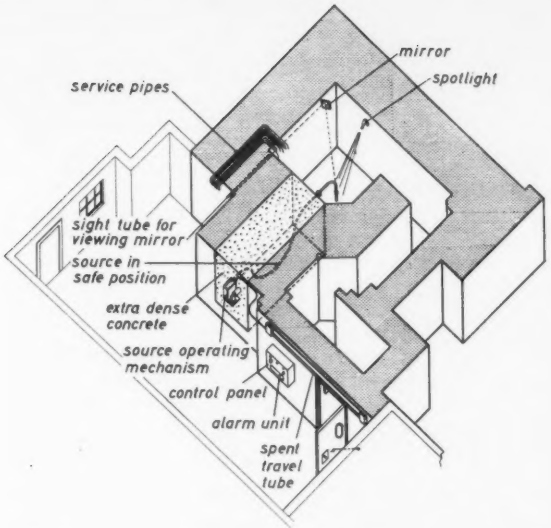


Fig 2 Irradiations are carried out in a heavily shielded cell with a labyrinth entry. Elaborate precautions are taken to ensure that personnel are not exposed to hazard

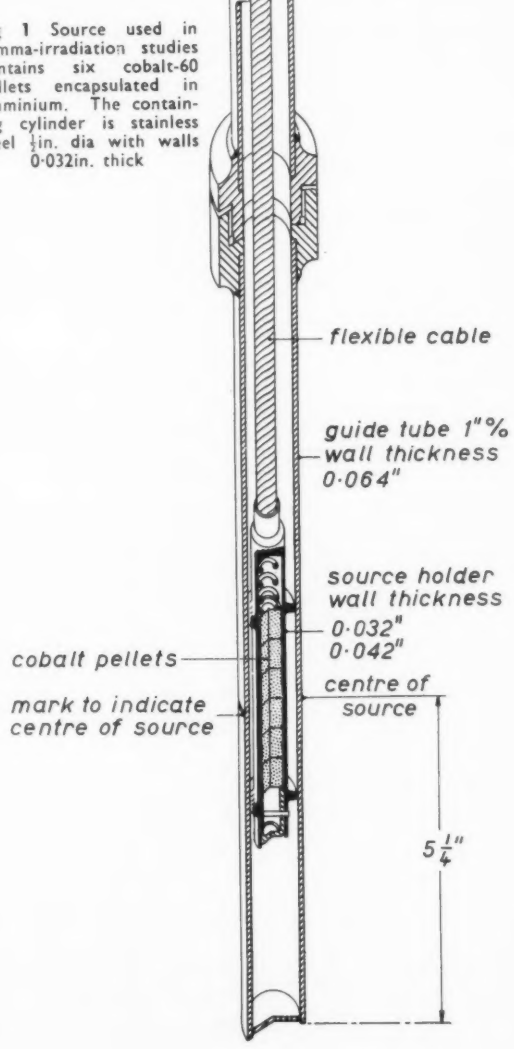


Fig 1 Source used in gamma-irradiation studies contains six cobalt-60 pellets encapsulated in aluminium. The containing cylinder is stainless steel ¼in. dia with walls 0·032in. thick

WHEN INITIAL SCHEMES for atomic power stations were being considered several years ago it was realized that the lubrication of the equipment in a nuclear power station would involve problems not previously encountered, and lubricants would be required having special properties such as resistance to atomic radiations. In February 1953 a programme was therefore started at Shell's Thornton Research Centre, in collaboration with the Atomic Energy Research Establishment at Harwell, on the effect of ionizing radiations on various lubricants.

A few months later Shell was consulted by C. A. Parsons Ltd. who were building the gas circulating plant for Calder Hall. The special lubricant which it was necessary to develop for this plant is now being supplied to Calder A and B stations.

Gamma irradiation

Since this programme of research was started four years ago a radiation laboratory has been built at Thornton where a cobalt-60 source providing intense gamma radiation has been installed. The Co-60 is in the form of pellets, six of which are sealed in an aluminium capsule contained in a stainless steel cylinder 3 inches long and ½ inch diameter with walls 0·032 inches thick (Fig 1). This cylinder is attached to a flexible steel cable, which moves the source within a 1 in. dia. stainless steel tube. Since a few minutes exposure to the gamma radiation from the source would be fatal, it is necessary to provide concrete shielding round it with a minimum thickness of about five feet (Fig 2). This shielding is constructed of concrete blocks which were staggered during the building so that there is no direct path for the radiation to escape to the outside along the joints. When experiments are in progress the source is in the exposed position at the end of the tube in the cell. Before the cell can be entered the source must be withdrawn up the tube until it lies within the loop in a specially dense mass of concrete. The system is equipped with an elaborate safety interlock system whereby the key to the door of the radiation cell also unlocks the operating mechanism (located in the control room) for the withdrawal or exposure of the source. When the source is in the exposed position it is impossible to remove this key from the mechanism operating the source: this can only be done when the source is safely

retracted. Similarly it is impossible to take the key from the door to operate the source mechanism unless the door is first securely closed and locked. As a further precaution however, the operator carries a gamma health tolerance meter as he walks through the labyrinth.

Samples to be irradiated are arranged around the source in specially shaped containers designed to make the maximum use of the radiation available (Fig. 3. Gamma rays, unlike neutrons, do not modify the nuclei of atoms they encounter so that no radioactivity is induced within the cell. It is therefore perfectly safe to enter the cell and examine the samples once the source has been withdrawn within the dense concrete block. The samples may be viewed during irradiation by an optical arrangement involving a mirror and spotlight (Fig 2). All the usual services—water, electricity, gas, compressed air and vacuum, are provided in the cell so that various experiments can be carried out under the influence of gamma radiation.

Chemical changes in lubricants

The cobalt-60 source emits gamma rays only, but some mechanisms of a nuclear power plant will be exposed to neutrons as well as to gamma rays. In the experiments done in collaboration with Harwell the samples were inserted into a nuclear reactor where they were subjected for various periods to a neutron flux of about 10^{12} thermal neutrons/cm^2/sec. together with the associated fast neutrons and gamma radiation.

Under ionizing radiation, molecules can absorb large amounts of energy. They become, in chemical terms, 'excited' and, depending upon their structure, can break down into highly reactive fragments. These fragments can then combine with neighbouring molecules to form compounds of higher molecular weight, as evidenced by significant increases in viscosity of the irradiated material. At the same time these changes are accompanied by the evolution of gases such as hydrogen and methane.

A very large number of materials, including a variety of synthetic as well as petroleum lubricants, have now been exposed to various dosages both of gamma radiation and neutrons. Examination of the samples after irradiation showed that many had undergone profound changes in molecular structure and physical properties. For example, certain conventional petroleum lubricants rapidly darkened in colour and increased in viscosity with increasing dosage of irradiation. They eventually became transformed into jelly-like masses with melting points in excess of 220°C and largely insoluble in petroleum spirit, cyclo-hexane, benzene, acetone, ethanol and ether. Similar effects were observed with some synthetic diesters and silicones.

This research work at Thornton has been planned to obtain information on the influence of molecular constitution of stability towards atomic radiations and already lubricants have been developed which show practically no change in physical properties at radiation dosages which transform many lubricants into solids. Fig 4 shows the effects of irradiation on a conventional lubricant.

Fig 3 Special glassware ensures efficient packing of the oil samples round the source unit

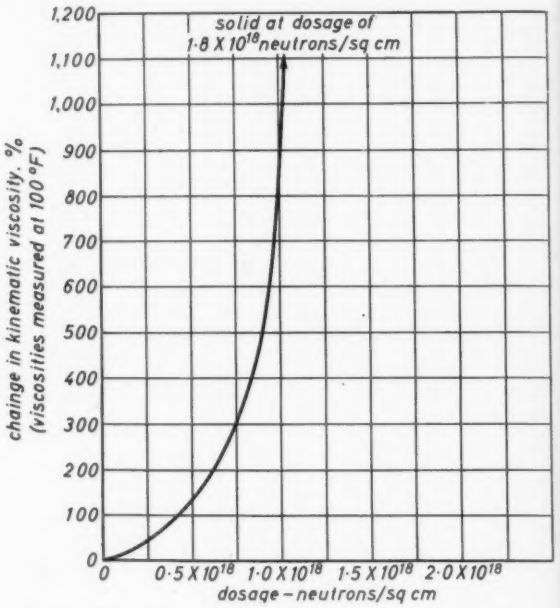


Fig 4 Conventional lubricant exposed to gamma irradiation displays a rapid increase in viscosity with dose. Shell report development of lubricants that resist this

Compatibility problems

In addition to resistance to radiation, other properties are required in the lubricants for equipment of nuclear power stations. For example, contamination of the reactor cannot be tolerated. Thus lubricants that might come in contact with the coolant gas of the reactors must have an extremely low vapour pressure. Also the lubricants must in some cases be capable of withstanding high temperatures for long periods since it may be possible to renew the lubricants only at intervals of several years. With this type of reactor there is also the problem of compatibility of the lubricant with hot coolant, e.g. carbon dioxide under high pressure.

As a result of research work in which the cobalt-60 source has played its part Shell have developed a number of special lubricants which are resistant to radiation and which meet the requirements of the nuclear power stations now being built for the CEA. These lubricants which will be supplied as *Shell Atomic Power Lubricants* (*APL*) have already been chosen for use in the Bradwell station of the CEA. Further research is continuing to develop lubricants still more resistant to radiation which will be required in future for more advanced designs of nuclear power plant.

XMM-Newton

XMM

B

IN
C

det

React
The
Calde
contr
pipes
Th
eerin

on s
ated
is do
ently
exter
Lloy
tion
radio
Ar
quire
x-ray

Ther
Pyro
are
temp
wall,
colu
tures

Bradwell

INDUSTRY'S CONTRIBUTION

details of some sub-contracts

Supplied and erected by Tees-Side Bridge and Engineering Works this steel tower will be used for erecting the Goliath crane

Reactor standpipes

The Unit Superheater & Pipe Co, following orders for Calder Hall and Chapel Cross, have received a Bradwell contract for the charge/discharge and control rod standpipes from Whessoe Ltd.

The assembly of the stand pipes requires precision engineering to produce the finished tubes to the close tolerances

Standpipes for Chapel Cross are all radiographed

on straightness required. This is not not normally associated with general pipework fabrication. All the welding is done with low hydrogen type electrodes to give consistently high radiographic results. The welds are ground flush externally and the bores of the tubes dressed smooth. Lloyd's Register of Shipping carry out 100 per cent inspection by plug gauging completed tubes and inspecting radiographs of the welds.

An idea of the amount of welding and radiography required can be judged from the minimum number of 6000 x-ray strip films for complete inspection.

Thermocouples

Pyrotenax M.I. Thermocouples and compensating cables are at present being installed at Bradwell for various temperature measurement applications, including the shield wall, pile raft, pile cap, thermal shield air duct and thermal column, and also for recording shell and lagging temperatures. Over 1500 thermocouples will be installed on these applications together with many thousands of yards of compensating cable. In addition, a considerable number of thermocouples have been specified for temperature recording on the actual reactors which of course are not installed until the later stages of construction.

Wired television

For inspecting the interior of the reactors, television equipment will be supplied by Pye Ltd. The camera is $3\frac{1}{2}$ in. o.d. and is 43-in. long, being able to view up to 20 ft in range. It will be lowered some 60 ft into the chamber and is CO_2-cooled. It can view in line and at right angles, adjustment being provided to vary the angle of view. By this means, welds at the base and the inside of the fuel tubes will be examined.

Grabs can be attached to the front of the camera, operated by motor inside the housing, the process of picking up small objects being viewed on a monitor.

Concrete curing

The strength of concrete and its resistance to abrasion and climatic conditions is greatly dependent upon proper curing. This was readily appreciated in the case of Bradwell where the concrete must be of the highest standard. Adequate curing necessitates the retention of the carefully measured mixing water until the chemical reactions of the cement and water are complete. In particular, surface evaporation must be carefully controlled. The first hours, in which the concrete is often unprotected, are the cause of much crazing and hair checking, which in turn are frequently followed by cracking or spalling.

At Bradwell, *Ritecure*, manufactured by Stuart B. Dickens Ltd will be used to give immediate protection during these vital hours and throughout the curing period.

Alloy steel forgings

For more than 100 years, Moss and Gamble Bros Ltd, have been making forgings—originally chiefly connecting rods and crankshafts etc, for large steam engines which were the then prime movers. Today, they are making forgings under the same steam hammers for use in connexion with nuclear power—the prime mover of the future.

As the years go by, the demand alters and now forgings are made in alloy steels where in the past, plain carbon steels were used. The majority of forgings are machined in

their works or rough machined for final finishing and fitting at the nuclear power station.

Crane motors

The British Thomson-Houston Co Ltd is supplying to the order of Clyde Crane & Booth Ltd. for NPPC twelve sets of equipment for overhead travelling cranes. Altogether thirty-nine motors, totalling 900 horsepower with control gear are being supplied. The hoist motions on all the cranes will be equipped with the BTH *Stacreep* control scheme.

Indicating temperature controllers

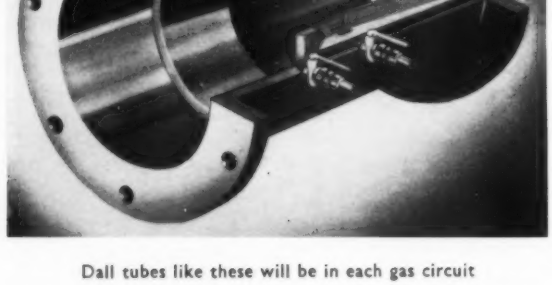
Instrumentation at Bradwell will include the following by Accurate Recording Instrument Co: indicating temperature controllers, fitted with mercury switches; oil pressure switches; winding temperature indicators fitted with remote repeater instruments; seal oil/gas differential pressure indicators, these indicators being fitted with alarm contacts, one contact for high and one contact for low differential alarm. A series of pressure gauges specially calibrated and fitted either with phosphor bronze or stainless steel Bourdon tubes, and oil flow indicators are also being supplied for use at the power station.

Exciter air filters

Air Control Installations Ltd's *Dustrap* filters, filled with coarse and fine nylon, are being supplied to C. A. Parsons & Co Ltd to be incorporated on the main exciter for the hydrogen-cooled alternators. The media used in these filters are one coarse and one fine knitted nylon pad, exclusive to this company, giving high efficiency and high dust holding capacity on a washable filter. No oil is needed and the filter medium itself is corrosion-proof.

Gas flow measurement

George Kent will be providing twelve 5ft dia. Dall tube liners for measurement of carbon dioxide flow in the primary coolant circuits. The Dall tube is a form of very short venturi tube developed by Kent's as a result of over 60 years' experience. It is shorter and lighter than the conventional short venturi tube and has a greater differential pressure recovery than the classical long venturi. The liner consists of a convergent-divergent section in brass or



Dall tubes like these will be in each gas circuit

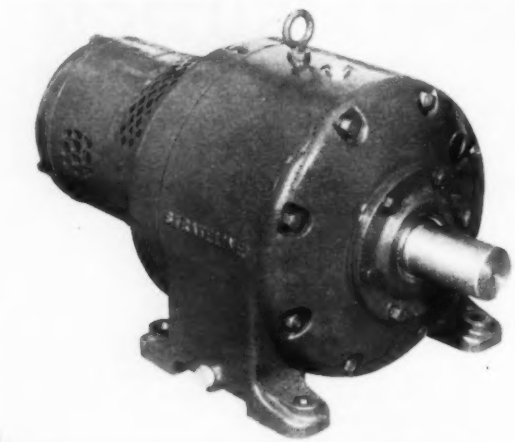
gunmetal and is enclosed in a parallel pipe. Pressure tappings are taken from the entry and from the throat which is a complete annular slot. The discharge coefficient of a Dall tube is constant over the whole flow range.

Another Kent item at Bradwell will be the single-point *Multelec* double-range conductivity recorder for turbine water purity and nine of these instruments will be supplied. This is a potentiometric strip chart instrument using the null point method of measurement.

Speed reducers

The charge/discharge machines will use *Strateline* speed reducers by Varatio-Strateline Gears Ltd. These are single or multiple stage units covering fixed ratios of from 3:1 to 1,000,000:1 or higher as required, and with output torque capacities of up to 60,000 lb in. The units are offered as motorized or non-motorized for mounting in any position.

The *Varatio* variable speed gear gives positive control



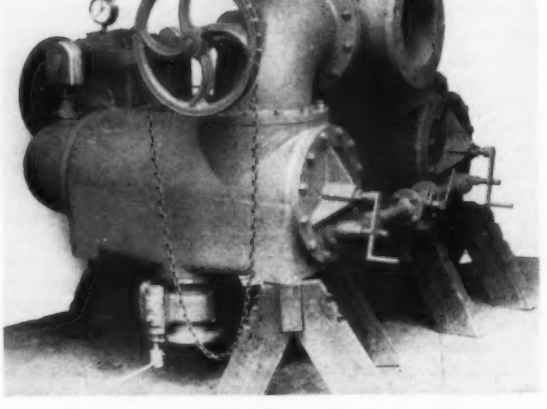
Motorized speed reducer similar to Bradwell type

through an all geared drive without slip or use of a clutch and is suitable for changing under full load and running conditions through a number of predetermined speeds. Standard units are offered with ratios of 2:1, 3:1 and 4:1 having 7, 9 and 13 output speeds respectively. Capacities range from $\frac{1}{2}$ to 50 h.p.

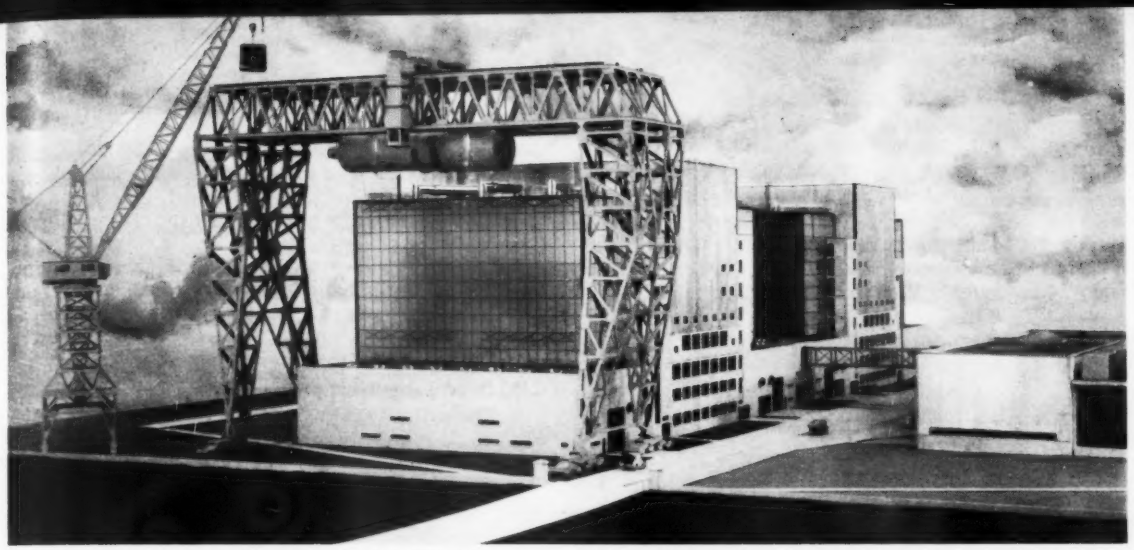
Water strainers

F. W. Brackett & Co Ltd will be providing at Bradwell the following self-cleaning Twin Strainers: six 14-in. bore, three 8-in. bore and six 6-in. bore. This equipment will be used for straining the auxiliary water supply for the air, water and oil coolers.

The main feature of the design is that there are two



Twin strainers will handle auxiliary water supplies



Main construction tool at Bradwell will be Goliath crane. With a 200-ton lift, it can handle complete boiler shells

bodies on each strainer, each containing a basket. By operating valves the water can be switched without interruption from a strainer fouled by rubbish to a clean basket. The dirty basket can be cleaned without removal from the body by internal jets operated by external control.

Differential indicators will be fitted to each strainer body to measure the head loss through each basket and to operate an alarm when the head loss exceeds a predetermined figure due to a blocked basket.

Goliath crane

In crane makers' parlance a goliath is usually any crane of the overhead girder type supported by legs carried on travelling runners, but the term is particularly appropriate in the case of the Booth Goliath Crane which is being built for the erection of Bradwell in view of its great size. The crane will completely straddle the reactor house, the four 16-wheel bogies running on standard gauge railway lines on either side. The crane is 178 ft high, about the same as Nelson's Column. It is 226 ft. in maximum width and, with a full load on the hook, will weigh over 1,000 tons.

The crane is now being erected on site and on completion its duties will be to handle all the materials and units involved in building the main part of the station. A 30 tons auxiliary hoist is provided for the smaller lifts but single items of equipment of up to 200 tons in weight can be lifted on the main hoist and placed with precision in the position required. All the motions of the crane are electrically operated, the current being supplied from a generating plant driven by a 440 hp diesel engine built into the structure of the crane.

This crane is not a permanent feature of the station but will be dismantled when the building is completed. By this time a number of Clyde Crane & Booth overhead travelling cranes will have been installed in the buildings thus providing crane coverage for the routine running of the station.

Pipe couplings

Viking Johnson couplings and flange adapters by the Victaulic Co Ltd are being used on 36-in. bore plain-ended cast-iron pipes to provide the necessary flexibility for thermal expansion of the circulating water mains at Bradwell. 54 in. Victaulic joints for use with cast iron pipes having Victaulic shouldered ends are also being supplied to this scheme. The problems of pipe laying are considerably reduced when jointed with these couplings.

Rotary water strainers

Six standard N size Hick Hargreaves rotary water strainers are being incorporated in the circulating water system. The design capacity of each of the strainers is 3,500,000 gph and the six units are capable of handling all cooling water requirements for the complete power station. The strainers, which will be installed on the discharge side of the main circulating water pumps, are designed to withstand a maximum test pressure of 65 psig. The size of the rotary strainer wheel is approximately 11 ft 6 in. diameter, the main casings being constructed in four sections from cast iron.

Modulating valves

Details of equipment to be supplied by Thermocontrol Installations Co Ltd are: 6-in. 3-way modulating control valves operated by potentiometric type motors; humidistats type HF; thermostats type TD and 24V 50 c/s shaded pole motors type M.

Storage batteries

For essential supplies to the reactors The Tudor Accumulator Co Ltd are supplying a standby battery composed of 216 cells in wooden lead-lined boxes with a capacity of 3600 amp-hours at the 10 hour rate. Station batteries with charging rectifiers and d.c. switchboards for switchgear operation and emergency supplies form the subject of another contract. This 800 amp-hours battery will have 112 cells in glass boxes.

Concrete fixings

One of the many suppliers in connexion with the building of Bradwell is the Unistrut Division of Sankey-Sheldon Ltd. It is estimated that they will supply over eight miles of Unistrut concrete inserts in the initial stages of the Bradwell project.

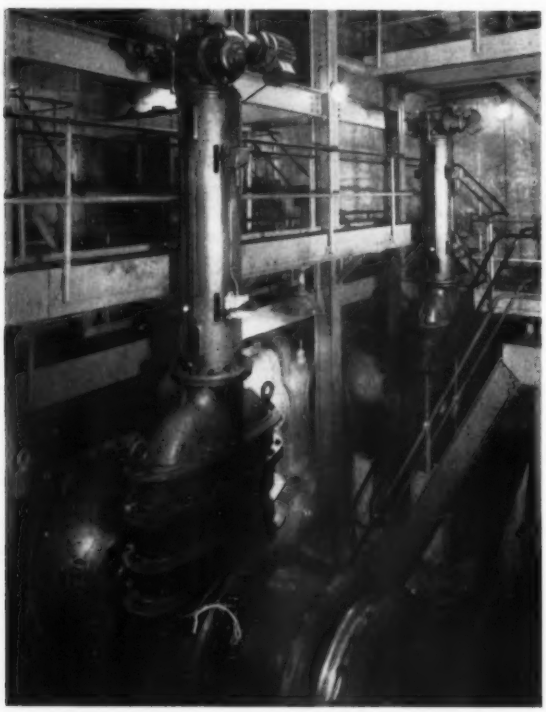
The Unistrut system provides multiple fixings from concrete surfaces without drilling, grouting, or other old-fashioned building techniques. The inclusion of these inserts will give contractors complete freedom for the location of many miles of pipes and cables which will be run before the installation is complete.

Chlorination plant

Wallace & Tiernan automatic vacuum metering chlorination plant will be available for treatment of the condenser cooling water to control marine growth in the intake circulating water system and to prevent slime fouling in the condensers. Automatic features exercise full supervisory control over the treatment rates and programmes, provision being made to minimize or entirely neutralize any chlorine content in the return water. The emphasis on safety and restraint in operation is supported by a comprehensive system of remote indicators and alarms with automatic cut-outs.

Water valves

Contracts to date for J. Blakeborough & Sons Ltd, cover the main circulating water valve equipment. For the Pumphouse Suction Dock: 8 ft by 8 ft, 5 ft by 7 ft, and 7 ft 6 in. by 9 ft 6 in. penstocks, rising spindle pattern, with weatherproof motor-operated headstocks. For the Pumping Plant: 54 in. diameter motor-operated sluice valves, tubular rising spindle pattern; and 54 in. multiple door pump non-return valves of Blakeborough Free-acting type. For main, auxiliary, and dump condenser connexions: motor-operated sluice valves in sizes from 21 in. to 39 in. diameter, tubular rising spindle pattern; and 30 in. diameter manually-operated butterfly valves of special design with rubber seating for tight shut-off.



Blakeborough pump discharge valves at a London power station

Valves and penstocks are of *Meehanite* high-duty cast iron with special trim. Electrically operated types—70 in all—are equipped with the standard Blakeborough motor gear unit, and in most cases with remote electrical position indicator. The free-acting non-return valves are a type specially developed for pump discharge duty, designed for shock-free closing and for application to high flow velocities without risk of mechanical trouble or undue hydraulic loss.

Rotor forgings

Thos. Firth & John Brown Ltd are supplying forgings as follows: h.p. and l.p. turbine shafts, alternator rotor shafts, rotor slip rings and end caps, fan cover plates and back plates, oil seal forgings, hydrogen seal rings, flanges and gearing forgings.

Reduction gearing

David Brown Industries Ltd, Keighley Gear Division, have been commissioned by Strachan and Henshaw Ltd, to supply helical and spur gears for the special four-stage reduction gearbox which will form part of the drive on the gantry travel, and also in the three-stage reduction gearbox for the charge machine travel gear. These combined travel gear mechanisms will serve all the charge/discharge tubes.

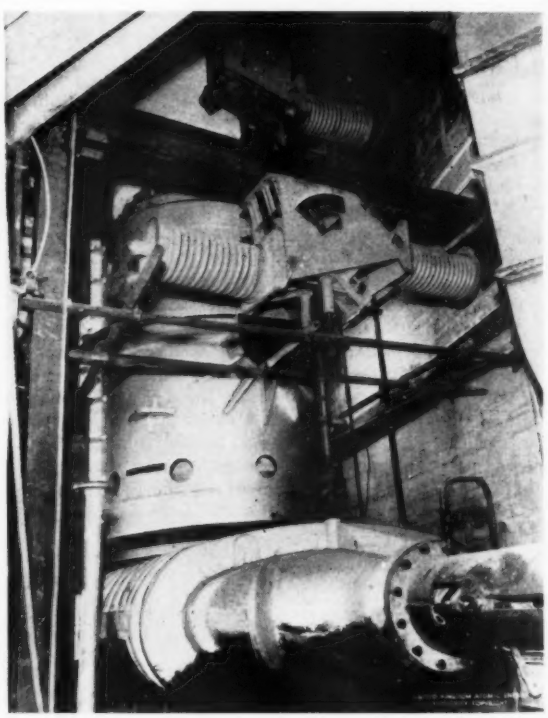
David Brown's Radicon Division will supply a number of *Radicon* worm reducers. These reduction gear units will be incorporated in the drive to the 'basket' and 'coffin' cranes which will handle the irradiated fuel in the cooling pond.

Circulator water treatment

For Bradwell, William Boby & Co Ltd are supplying equipments for chemically dosing the gas circulator cooling water to inhibit corrosion and prevent scale deposition. The treatment will be the addition of controlled doses of tannin/phosphate/sodium carbonate into a closed circuit for the maintenance of the necessary number of concentrations in the cooling water circuit. In addition, they are providing base exchange treatment for the feed water requirements of the temporary economic boilers used for the construction of the power station. When the need for this supply ceases, the Boby plant will be available for other permanent duty.

Duct hangers

Vokes *Genspring* constant support hangers, Types W.3, W.4 and H.12, have been specified for the support of the main CO_2 gas lines running from the reactor to the heat exchanger and return. Adequate and safe support for these lines is absolutely essential in view of the large thermal movements and weights involved.



At Calder Hall, Genspring W3 and W4 hangers support ducting

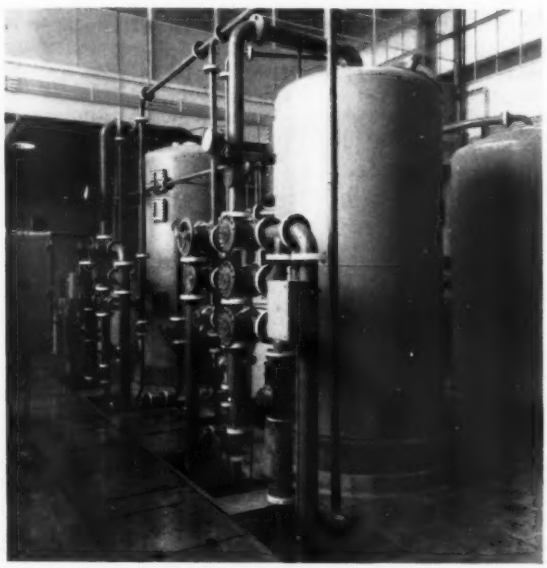
In addition, Vokes Genspring Ltd are supplying all necessary equipment such as turnbuckles, rods, beams, etc., for attaching the hangers to the ducting and for supporting the ducting.

Condenser tubing

For many years The Birmingham Battery and Metal Co Ltd have specialized in the manufacture of high-grade non-ferrous tubes and tube plates for power station condensing plant and their *Batalbra* aluminium brass tubes and their large *Batnaval* condenser plates have been ordered for the world's first nuclear power stations—Calder Hall B, Chapel Cross and Bradwell. Over 115 tons of tubes and plates will be going into the main and dump condensers at Bradwell.

Demineralization plant

A Permutit Mixed Bed *Deminrolit* Plant will be installed to treat the heat exchanger feed water. This plant operates by ion exchange and provides a demineralized feed water



Bradwell will have 'Deminrolit' plant similar to this

with the following characteristics: Conductivity 0·5 reciprocal megohms at 20°C, not more than 0·5 p.p.m. of silica as SiO_2 and not more than 0·5 p.p.m. total dissolved solids (including silica). The plant consists of two Mixed Bed units rated to treat up to 10,000 gallons of water hourly. Each unit contains a bed of intimately mixed Permutit *Zeo-Karb* cation exchange material and *De-Acidite* highly basic anion exchange material.

Air compressors for test

For testing the reactor pressure vessels to 300 psig, the compressor plant is divided into two sections. To keep the capital cost as low as possible the first stage is by contractors' compressors up to 100 psig. From this point Belliss and Morcom Ltd will provide a cooler and receiver in which a large proportion of oil and moisture is separated out. The air then passes to four motor-driven single-stage reciprocating boosters bringing up the pressure from 100 to 300 psig and delivering finally through aftercooler and oil remover. Each booster is controlled to ensure that it cannot be overloaded by deficiency on the part of the first stage compressors.

Shield cooling fans

Eight double-inlet *Sirocco* fans will be installed to induce a flow of cooling air between biological and thermal shields. Four of these fans will be situated near the top of each reactor. Manufactured by Davidson & Co Ltd, Belfast, they are of the well proved high efficiency backward aerofoil bladed design, many examples of which provide draught in conventional power stations and in mine ventilation. Special features of these shield cooling fans include ample standby capacity, the fans being of the non-overloading type.

Motor control gear

Brookhirst Switchgear Ltd are supplying 415 V motor control gear for the auxiliary plant at Bradwell. This will include 43 grouped starter switchboards and a large number of separately mounted starters for turbine auxiliaries and reactor essential auxiliaries, fuel element handling plant, control rods and safety rods.

In all, there will be equipment for controlling and protecting some 550 drives. Most starters will be direct-on automatic type basically comprising contactors to BS587:1957, overcurrent relays, and isolating switches. Latch-in type contactors will be employed for all essential auxiliaries to prevent shut-down in the event of a brief supply failure. Complex electrical interlocking schemes will be incorporated for some groups of drives.

Temporary buildings

Terrapin Ltd have supplied a large range of their mobile buildings. Within two days of site access the main Civil Engineers and the Resident Engineer were occupying office and toilet accommodation of approximately 2500 sq. feet and temporary dormitory accommodation of approximately 2000 sq. feet.

The main NPPC offices of approximately 6000 sq. feet were delivered, erected between the 12th and 20th February and the CEA offices of approximately 4000 sq. feet followed in the following fortnight. Approximately 55,000 sq. feet of dormitory accommodation, complete with ablutions, canteen and office block were supplied, delivered and erected ready for occupation in something under 8 weeks. The whole of the accommodation is heated by means of Terrapin mobile oil fired boiler houses, which are, in themselves, a complete automatic installation.

A break followed until early in May when erection commenced of the recreation block for the camp area (approximately 5000 sq. feet) and the site canteen to feed up to 3000 of approximately 15,000 sq. feet floor area.

During construction Terrapin buildings are used extensively

Later, due to the shortage of hotel accommodation in the area and the difficulties this caused by way of transport, time wastage, etc., it was decided to erect special accommodation for Senior Executives visiting or working on site.

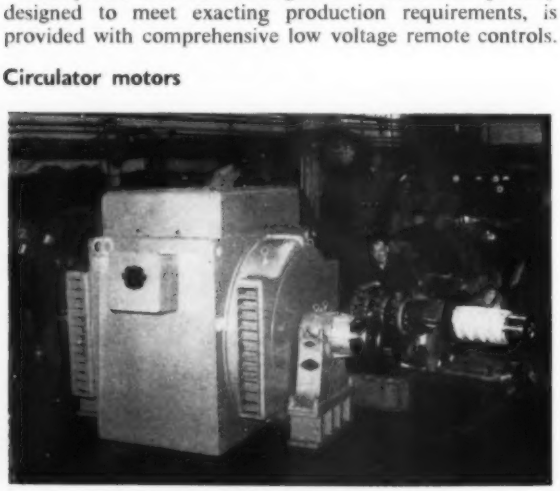
Approximately 92,500 sq. feet of accommodation—enough for 500 men—were completed ready for occupation during a period of something less than 6 months from date of order.

Turning rolls for boiler making

Donald Ross & Partners Ltd are supplying to Head Wrightson Teesdale Ltd specially designed manipulating plant designed for lining up, rotating and traversing heat exchanger sections during welding, stress-relieving, X-ray inspection, shot blasting and final pressure test. The main plant consists of three sets of *Twinner* self-propelled turning rolls, each set comprising three independent motorized trolleys carrying a number of driving and idling turning roll units. The roll carriages of all units are fitted with a special mechanism for withdrawing the turning rolls during stress-relieving operations. The total carrying and rotating capacity of each set is 225 tons. Four revolving columns 27 ft high mounted on motorized trolleys with elevating arms for carrying automatic welding heads will be supplied—also one set of *Twinner* turning rolls of 225 tons capacity for final pressure testing.

This plant, which is the largest of its kind and specially designed to meet exacting production requirements, is provided with comprehensive low voltage remote controls.

Circulator motors



A prototype 4400 hp motor for Bradwell

Lancashire Dynamo machines on order for Bradwell total over 60,000 h.p. and range from specially designed high-speed gas circulating motors to small valve-operating motors, together with stand-by generators for essential station services, fan, pump, crane and compressor motors and various turbine auxiliaries.

Gas driers

Equipment for gas drying in the recirculation systems of the nuclear reactors at Bradwell is being provided by Birlec Ltd, who are supplying similar driers for Berkeley, Hunterston and Dounreay.

Two adsorption driers are being provided for each reactor, each consisting basically of two cylindrical chambers filled with activated alumina. The two chambers are interconnected by valves so that while gas is being dried in one, used material in the other may be reactivated by means of a built-in heater. Continuous drying is obtained by automatic changeover of the valves.

CO_2 enters the driers at 132 psig and with a maximum temperature of 356°F. It is split into two streams, the smaller of which is taken directly through a three-way valve to the reactivation boost heater and thence passed in a reverse direction through one cylinder to reactivate the alumina. The other stream, comprising the major part of the flow, is first passed through heat exchange equipment for cooling, as drying can be carried out effectively only at temperatures in the region of 100°F. It is then passed through the actual drier unit.

This type of drier is capable of removing 3 lb of moisture per hour from the process gas flow of 10,300 lb per hour with a humidity content of ·0003 lb per lb.

Bolt heating

Backer bolt-heating equipment will be used to ensure truly steam-tight joints on the high pressure plant. Essentially the heater comprises a high temperature nickel-chrome sheathed element housed in a circular aluminium bronze sheath designed to be a close fit in the bolt bore. Careful design of individual heaters ensuring application of heat only where intimate contact is secured ensures maximum speed and efficiency.

After hand tightening all nuts the heaters are inserted into diametrically opposite bolts and switched on to either mains or low voltage supply. The heat input is rapid and produces a bolt elongation, before the frame also expands, of sufficient length to allow further tightening of the nut. As the bolt contracts a steam-tight joint is produced which can only be released by a further application of the heaters and reversing the procedure. Heaters are available for voltages of 110 to 440V and for bolt bore sizes of from 41/64 in. to 1¾ in.

Oil seal valves

Among the many special valves which Blagdon Engineering Co Ltd manufactures for C. A. Parsons & Co, are the oil seal differential control valves for Bradwell. The internal working parts of these valves are machined to fine limits and particular care must be taken in their assembly. Other precision work undertaken by this firm includes gas turbine burners, manometers, test rigs and work of a similar nature.

Boiler circulation pumps

Forty-eight glandless circulators and coolers are being manufactured by Hayward Tyler and Co Ltd for supply to Clarke, Chapman and Co Ltd. These will be used for h.p. and l.p. boiler circulation duties at Bradwell. Similar pumps have also been ordered for both Berkeley and Hunterston, thus giving the firm the unique distinction of having supplied boiler circulation pumps for every British nuclear power station. The Bradwell order is worth

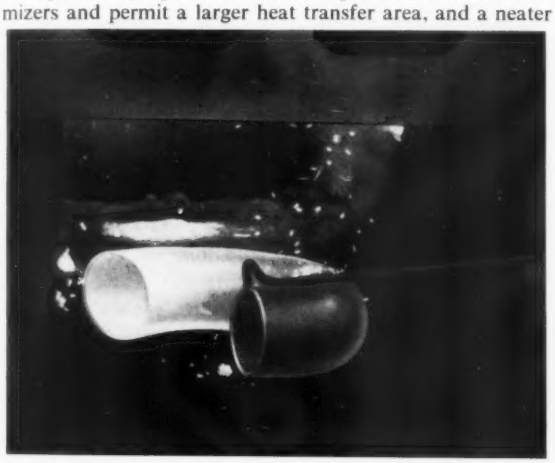
Boiler circulators will be Hayward Tyler glandless

£140,000; with Berkeley and Hunterston, HT's orders for this type of pump amount to £430,000.

Features of the Hayward Tyler pump can be seen in the drawing. Pump and motor are mounted on the same shaft in a common casing thus eliminating alignment problems. Cooling of the plastic-insulated stator windings and lubrication of the reinforced phenolic resin bearings is by water which is circulated by an auxiliary impeller and cooled in a small external heat exchanger. A thermal baffle is incorporated just below the main impeller to minimize heat transfer from the hot boiler water to the motor. Hayward Tyler have been making pumps since 1815 and glandless types since 1940. Recently the company joined the Platt Bros. and Co (Holdings) Ltd Group.

Forged tube bends

BKL Alloys Ltd, Kings Norton, Birmingham, 30, are supplying for Bradwell, tens of thousands of return bends to very close tolerances. These are used in the construction of high and low pressure boilers, superheaters, and economizers and permit a larger heat transfer area, and a neater



A return bend in the making at BKL Alloys' works

arrangement of pipes inside the unit than is possible by conventional methods.

The BKL process guarantees true circularity of bore throughout the bend without any thinning of the wall. The firm have already supplied carbon and stainless steel elbows to meet the exacting requirements and special conditions of the DIDO type test reactors at Harwell and Dounreay.

Main gas valves

The equipment to be supplied by Hopkinsons Limited comprises reactor valves, boiler mountings, pipe line valves, turbine valves, reducing and desuperheating equipment and centrifugal separators (for purifying turbine oil). The contracts include 60 in. and 36 in. bore *Tansphere* valves, with motor operation, for CO_2 control in the main ducting to and from the reactor. The boiler mountings include *Hylif* safety valves, whistle alarms, water gauges, pressure gauges, combined stop and non-return valves, Hopkinson-Ferranti valves, parallel-slide valves, *Uniflow* valves, electric controls, etc., and the pipe valves comprise receiver valves, drain valves, steam to dump condensate sprays and feed valves. The turbine valves include LP heater, auxiliary and bled steam valves and steam traps.

Bodies for the twelve 60-in. *Tansphere* valves will be fabricated in mild steel by Yarrow & Co Ltd.

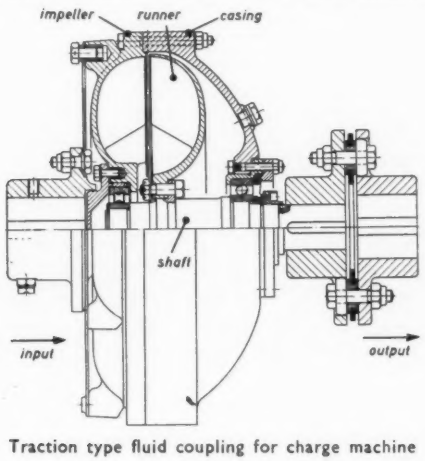
Instrument air compressors

Reavell & Co Ltd have an order from NPPC for four SAN.7E single-acting, single-stage, single-cylinder, carbon-ring, oil-free air compressors, each to supply 50 cu. ft of free air per minute at a pressure of 100 psi for operating instruments. Motor-driven, the compressors operate in pairs and are arranged for automatic stopping and starting or for continuous running unloading.

The air from the carbon ring compressors of course contains no oil, but to eliminate any water drawn in with the atmospheric air each compressor is provided with an aftercooler separator followed by a Visco duplex pressure filter and finally by silica gel dual-adsorber driers giving a dew point of 0°C. or less at the pressure of 100 psi.

Hydraulic couplings

Fluidrive Engineering Co Ltd are constructing, to the order of C. A. Parsons & Company Ltd, 11 SSS clutches, rated at 4000 lb. ft, for fitting between the main and pony motors driving the gas circulators. The purpose of the clutch, which is both self-engaging and disengaging, is to enable the pony motor to start up the gas circulator and also, when the main motor takes over the drive to disengage automatically the pony motor in a shockless manner. Eleven SSS clutches will also be fitted to an extension of the main motor shafts to prevent rotation in the reverse direction should such a circumstance arise.



Traction type fluid coupling for charge machine

For the pony motors driving the Davidson circulating gas fans, a further 8 SSS clutches are being supplied.

In the case of the charging machines being constructed by Strachan & Henshaw Ltd, eight size 16·25 Vulcan-Sinclair fluid couplings of the traction type are being supplied for the long travel motions. In each case these fluid couplings, as shown in the sectional drawing, will be driven by direct-on-started squirrel-cage motors rated at 10 hp at 720 rpm, the main purpose being to give maximum flexibility of drive.

Neutron source tubes

The first commercial production in this country of neutron source tubes is being undertaken by the Tube Investments subsidiary, Talbot Stead Tube Co Ltd, on behalf of the NPPCo. The tubes consist of an antimony rod surrounded by a beryllium tube and enclosed in an outer sheath of stainless steel. Irradiation in a reactor produces Antimony-124 whose 1·71 MeV gamma rays produce a gamma-neutron reaction in the beryllium. The energy of the neutrons is about 25 to 30 keV. This neutron source is used to initiate the chain reaction in a reactor under controlled conditions.

Besides the starter tubes, Talbot Stead's contracts—worth about £750,000—will include: short charge plugs, absorber rods, fuel element support assembly, control rods, control rod standpipes, and charging standpipes.

BRADWELL: list of contractors

The 300MW nuclear power station is being designed and constructed by:

THE NUCLEAR POWER PLANT CO., LTD.

Booths Hall, Knutsford, Cheshire

Member and Associated Companies of the group are:

C. A. PARSONS & CO LTD, Heaton Works, Newcastle-on-Tyne, 6 *Turbogenerators, transformers, condensers, feed heaters, circulators, ductwork, instrumentation*

A. REYROLLE & CO LTD, Hebburn, Co Durham *Switchgear, control gear*

HEAD WRIGHTSON & CO LTD, Teesdale Iron Works, Thornaby-on-Tees *Reactor equipment, heat exchangers*

SIR ROBERT McALPINE & SONS LTD, 80 Park Lane, London, W1 *Civil engineering, buildings*

WHESSOE LTD, Darlington, Co Durham *Reactor shells*

STRACHAN & HENSHAW LTD, Steelhoist Works, St. Philips, Bristol *Fuel handling equipment*

ALEX FINDLAY & CO LTD, Motherwell, Lanarkshire *Structural steel, general fabrication*

CLARKE, CHAPMAN & CO LTD, Victoria Works, Gateshead, Co Durham *Steam raising equipment, cranes and lifting equipment.*

By the time it is finished the construction of Bradwell power station will have involved about 1000 firms in greater or less degree. The following list gives the first subcontracts to be announced, with the firms arranged under the appropriate main contractors.

THE NUCLEAR POWER PLANT CO LTD

G. ACTON, Knutsford *lighting fittings*
G. ANGUS & CO LTD, Manchester *fire tender equipment*
J. BLAKEBOROUGH & SONS LTD, Brighouse *valves*
W. BOBY & CO LTD, Rickmansworth *water softening plant*
BROOM & WADE LTD, High Wycombe *air compressors*
CROSSLEY BROS, Manchester *diesel alternator sets*
DAVEY PAXMAN & CO LTD, Colchester *boilers*
EASTERN ELECTRICITY BOARD, Brentwood *labour camp cables*
P. J. FOSTER & CO LTD, Manchester *surveying equipment*
W. T. GLOVER & CO LTD, Manchester *cables*
HICK HARGREAVES & CO LTD, Bolton *rotary water strainers*
HOLDEN & BROOK LTD, London *pumps*
INDUSTRIAL FIRST AID SUPPLIES, Manchester *ambulance equipment*
MATHER & PLATT LTD, Manchester *drainage pumps, fire protection equipment*
D. MATTHEWS & SON LTD, Liverpool *office furniture*
PERMUTIT CO LTD, London *water treatment plant*
J. A. PHIBBS LTD, Knutsford *ambulances, fire engines*
POST OFFICE TELEPHONES, Southend-on-Sea *telecommunications equipment*
PYROTENAX LTD, Hebburn *thermocouples*
REAVELL & CO LTD, Ipswich *instrument air compressor sets*
SELF-MOTORING, Ipswich *petrol pumps*
SHELL-MEX AND BP LTD, Ipswich *fuel tanks*
W. H. SMITH & CO LTD, Manchester *electrical installations*
THE STANTON IRONWORKS CO LTD, Nottingham *pipework*
STAVELEYS LTD, Atherton *site storage buildings*
TERRAPIN LTD, London *site buildings*
UKAEA, Risley *graphite*
VICTAULIC CO LTD, London *couplings, adaptors*
WALLACE & TIERNAN LTD, London *chlorination plant*

C. A. PARSONS & CO LTD

ACCLES & POLLOCK LTD, Birmingham *stainless steel tubes*
ACCURATE RECORDING INSTRUMENT CO, Morden *temperature indicators*
AIR CONTROL INSTALLATIONS LTD, Ruislip *filters*
GEORGE ANGUS & CO LTD, Wallsend-on-Tyne *sealing rings, driving wheels*
APPLEBY-FRODINGHAM STEEL CO, Scunthorpe *steel plates*
ATLAS STEEL FOUNDRY AND ENGINEERING CO LTD, West Lothian *steel chests*
AUTOMOTIVE ENGINEERING CO LTD, Twickenham *circlips*
BACKER ELECTRICAL CO LTD, Rotherham *bolt heating elements*
BIRMINGHAM BATTERY & METAL CO LTD, Birmingham *condenser tubes and plates*
J. BEAMONT & SONS LTD, Newcastle *nyloc nuts*
WM. BEARDMORE & CO LTD, Glasgow *forgings*
BLAGDON ENGINEERING CO LTD, Seaton Burn *pressure control valves*
J. BLAKEBOROUGH & SONS LTD, Brighouse *exhaust valves*
F. W. BRACKETT & CO LTD, Colchester *strainers*
BRITISH ERMETO CORPN LTD, Maidenhead *steel tees and elbows*
BROWN, BAYLEY STEELS LTD, Sheffield *stainless steel forgings*
CHESTERFIELD TUBE CO LTD, Chesterfield *receiver bodies*
CHARLES CHURCHILL & CO LTD, Gateshead *screws*
COLVILLES LTD, Glasgow *steelwork*
CONSETT IRON CO LTD, Co. Durham *dished end plates*
CRAIG & DERRICOTT LTD, Sutton Coldfield *miniswitches*
CRANE PACKING CO LTD, Slough *mechanical seals*
CROFTS (ENGINEERS) LTD, Bradford *flexible couplings*
DARLINGTON FORGE CO, Darlington *forgings*
DENNYSTOWN FORGE CO LTD, Dumbarton *forgings and adaptors*
DORMAN, LONG (STEEL) CO LTD, Redcar *steel plates*
DUNLOP RUBBER CO, Manchester *silicone rubber seals*
ENGLISH STEEL CORPORATION LTD, Sheffield *rotor shaft forgings*
ENGLISH STEEL FORGE AND ENGINEERING CORPORATION, Sheffield *flanges*
EVA BROS LTD, Manchester *forged steel flanges*
THOMAS FIRTH AND JOHN BROWN LTD, Sheffield *forged steel flanges*
FIRTH-VICKERS S.S. LTD, Sheffield *forgings*
THE FLUIDRIVE ENGINEERING CO LTD, Isleworth *clutches*
JOHN FOLKES (LYE FORGE) LTD, Stourbridge *shaft forgings*
FOUNDROMETERS LTD, Leeds *revometers*
S. FOX & CO LTD, Sheffield *steel bars*
FULLER ELECTRIC MANUFACTURING CO LTD, London *tapchanging equipment*
GENERAL RADIOLOGICAL LTD, London *flux monitoring system*
GUEST, CHRIMES LTD, Rotherham *sluice and non-return valves*
HARLAND ENGINEERING CO LTD, Alloa *boiler feed pumps*
G. A. HARVEY & CO LTD, London *ball floats*
HATTERSLEY LTD, Ormskirk *valves*
HEWELL SPRING CO LTD, Redditch *steel springs*
HOFFMAN MANUFACTURING CO LTD, Chelmsford *ball bearings*
HOPKINSONS LTD, Huddersfield *gas valves, oil purifiers, valves and pumps*
I.C.I. LTD, Newcastle *copper gas cooler ferrules*
JARROW TUBE WORKS LTD, Jarrow *tubing*
ROBERT JENKINS & CO LTD, Rotherham *ducts, casings etc.*
G. KENT LTD, Luton *dall tubes, instruments*
R. KLINGER LTD, Sidcup *joints, level gauges*
LAMBTON CONSTRUCTION CO LTD, Philadelphia, Durham *mild steel rings, steel plate*
LANCASHIRE DYNAMO & CRYPTO LTD, Manchester *electric motors*
F. H. LLOYD & CO LTD, Wednesbury *cylinder centre covers*
MANGANESE BRONZE & BRASS CO LTD, Ipswich *oilite plates*
MORGAN CRUCIBLE CO LTD, London *carbon rings*
JOHN MOUNTFORD & CO LTD, Manchester *forgings*
THE NATIONAL STEEL FOUNDRY LTD, Leven *diffusers, gland housings, and pedestal ends*
NEGRETTI & ZAMBRA LTD, London *thermometers*
S. OSBORNE LTD, Sheffield *circulator inlet casings*
SIR H. G. PARSONS & CO LTD, Newcastle *reactor viewing equipment*
T. B. PEARSON & SONS LTD, Newcastle *cover domes*
POWER FLEXIBLE TUBING CO LTD, London *bellows units*
REDHEUGH IRON & STEEL CO LTD, Gateshead *steel plates*
REDPATH, BROWN & CO LTD, Edinburgh *steelwork*
G. SALTER & CO LTD, West Bromwich *springs*
J. SANKEY & SONS LTD, Bilston *cascade vanes*
SANKEY, SHELDON LTD, Leeds *concrete inserts*
SIGMUND PUMPS LTD, Gateshead *water pumps*
SMITHS INSTRUMENTS LTD, London *tachometers*
SOUTH DURHAM STEEL & IRON CO LTD, Middlesbrough *durbar chequer plates*
W. SPENCER LTD, Sheffield *steel plates*
STEATITE & PORCELAIN LTD, Stourport *bushings*
THE STEEL COMPANY OF WALES LTD, Newport *core plates*
STEWARTS & LLOYDS LTD, Newcastle *tubing*
TALBOT STEAD TUBE CO LTD, Walsall *absorber and control rods, neutron source assemblies*
THERMOCONTROL INSTALLATIONS LTD, London *thermostats, humidistats*
RICHARD THOMAS & BALDWIN LTD, Brierley Hill *stator core plates*
R. TRIST & CO LTD, Slough *seals*
VICKERS-ARMSTRONG (ENGINEERS) LTD, Newcastle *munz metal plates*
VICKERS-ARMSTRONG LTD, Newcastle *tube plate blanks*
VOKES GENSPRING LTD, Guildford *support hangers*
VOKES LTD, Guildford *filters*
WELDLESS STEEL TUBE CO LTD, Wednesfield *tubing*
WHIPP & BOURNE LTD, Rochdale *switchgear*
YARROW & CO LTD, Glasgow *fabrication of gas valve bodies*
THE YORKSHIRE COPPER WORKS LTD, Leeds *brass/aluminium tubes*

A. REYROLLE & CO LTD

BRITISH INSULATED CALLENDERS CABLES CO LTD, London *cables*
BROOKHIRST SWITCHGEAR LTD, Chester *contactor gear*
BROWN BAYLEY STEELS LTD, Sheffield *steel plate, rod and bar*
CROSSLEY BROS, Manchester *diesel engines*
LANCASHIRE DYNAMO & CRYPTO LTD, Manchester *motor alternator sets*
STANDARD TELEPHONE & CABLE CO, London *telephone type alarm equipment*
TALBOT STEAD TUBE CO LTD, Walsall *stainless steel tubing*
TUDOR ACCUMULATORS LTD, London *standby batteries*

HEAD WRIGHTSON & CO LTD

J. ADAMSON & CO LTD, Hyde *steel dished ends*
W. BEARDMORE & CO LTD, Glasgow *support plates*
BROWN, BAYLEY STEELS LTD, Sheffield *steel flange rings*
THE CONSETT IRON CO LTD, Consett *steel plates, etc.*
DAVIDSON & CO LTD, Belfast *shield cooling fans*
DORMAN, LONG & CO LTD, Middlesbrough *steel plate*
THOMAS FIRTH and JOHN BROWN LTD, Sheffield *steel forgings*
JOHN FOLKES LTD, Stourbridge *steelwork*
HADFIELDS LTD, Sheffield *forged steel rings*
I.C.I. (METALS) LTD, Birmingham *integron tubing*
DONALD ROSS & PARTNERS LTD, Crawley *positioning equipment*
ROYAL ORDNANCE FACTORIES, Birtley *machining of thermal sleeves*
SOUTH DURHAM STEEL & IRON CO LTD, Middlesbrough *steel plate*
STEEL, PEECH & TOZER LTD, Sheffield *steel bars*
STEWARTS & LLOYDS LTD, Birmingham *steel tubes*
VACU-BLAST LTD, Slough *shot blasting machine*

SIR ROBERT McALPINE & SONS LTD

EDWARD ASH LTD, Deptford *sleepers*
J. BLAKEBOROUGH & SONS LTD, Brighouse *cooling water penstocks*
BROOKES CHEMICALS, LTD, London *bituminous emulsion*
BUILDERS IRON & ZINCWORK LTD, London *copper expansion jointing*
BROADS MANUFACTURING CO LTD, London *manhole covers*
BROWN & SONS LTD, Chelmsford *fencing, asbestos cement sheets*
CEMENTATION CO LTD, London *bored piles*
CEMENT MARKETING CO LTD, Grays *cement*
CHRISTIE & VESEY LTD, Charlton *timber*
CROFT GRANITE CO LTD, London *granite chippings*
CLAY CROSS LTD, Chesterfield *cast-iron pipes*
DAVIDSONS PAPER SALES LTD, London *building paper*
DOULTON & CO LTD, London *S.G. conduits*
DUDLEY & DOWELL LTD, Cradley Heath *manhole covers*
EXPANDITE LTD, London *jointing and water-stop*
EDWARD FARR LTD, Wickford *CO_2 liners*
FENCING LTD, Walton-on-Thames *fencing*
B. FINCH & CO LTD, Barkingside *fire hydrants*
GKN (SOUTH WALES), LTD, Cardiff *concrete reinforcement bars*
GABRIEL, WADE & ENGLISH LTD, London *timber*
GROOM, DANIELS & CO LTD, Colchester *timber, asbestos cement sheets*
GEORGE E. GRAY LTD, Ilford *timber*
GLENFIELD & KENNEDY LTD, Kilmarnock *manhole covers, reservoir fittings*
HALES CLINKER LTD, London *filter media*
HEPWORTH IRON CO LTD, Sheffield *S.G. conduits*
HENRY LINDSAY LTD, Bradford *steelwork connectors*
HOLLIDAY, HALL & STINSON LTD, London *electrical installations—site temporary buildings*
JOHN LENANTON & SON LTD, London *timber*
KENT, BLAXHILL & CO LTD, Colchester *glass and glazing materials*
LONDON BRICK CO LTD, Fletton *bricks*
MERRYWEATHER & SONS LTD, London *fire equipment*
MUNRO & MILLER LTD, Glasgow *storage hole liners*
M.B. DREDGING CO LTD, Erith *dredging contractors*
F. A. NORTON & SONS LTD, Bradwell Pit *concrete aggregate*
NATIONAL REYWOOD CO-OP LTD, London *timber*
NUTS AND BOLTS (DARLASTON) LTD, Darlaston *nuts and bolts*
PETERS & BARHAM LTD, Tillingham Pit *concrete aggregate*
G. J. PALMER & SONS, London *filter media*
R. PASSMORE & CO LTD, London *asbestos cement sheets*
E. REVELL & SONS LTD, Welling *cardboard tubes*
JOHN SADD & SONS LTD, Maldon *timber, fencing, joinery, asbestos cement sheets*
SOUTH DURHAM STEEL & IRON CO LTD, Middlesbrough *steel sheet piles*
W. T. STORER LTD, Barking *timber*
SPICERS LTD, London *cardboard tubes*
STONEWARE LTD, Tamworth *stoneware pipes and fittings*
STANTON IRONWORKS CO LTD, Nottingham *cast-iron pipes*
STAVELEY IRON CO LTD, Chesterfield *cast-iron pipes*
SPUN CONCRETE LTD, Rye, Sussex *concrete pipes*
STEWARTS & LLOYDS LTD, Birmingham *M.S. tubing*
SANKEY, SHELDON LTD, London *unistrut concrete inserts*
STUART B. DICKENS, Borehamwood *waterproofing liquid*
TWISTEEL REINFORCEMENT LTD, London *fabric reinforcement*
THE EXPANDED METAL CO LTD, London *brick reinforcement*
THOMAS ALLAN & SONS LTD, Thornaby-on-tees *cast-iron pipes*
TURNERS ASBESTOS CEMENT CO LTD, Manchester *asbestos cement pipes*
THAMES BANK IRON CO LTD, London *fire hydrants*
THOS. W. WARD LTD, Sheffield *crane and rail track fittings*
W. & C. TIPPLE, LTD, London *sundry steel fittings*
TERRAPIN LTD, London *site temporary buildings*
WELFORD GRAVELS LTD, Tillingham Pit *concrete aggregate*
WHITEHEAD IRON & STEEL CO LTD, Newport *M.S. E.H.T. reinforcement*
W. H. WILLCOX & CO LTD, London *rubber joint rings*
WILLIAMS & WILLIAMS LTD, London *metal windows*

WHESSOE LTD

THE APPLEBY-FRODINGHAM (STEEL) CO, Scunthorpe *steelwork*
BARR, THOMSON & CO LTD, Kilmarnock *flanges*
CHATWOOD MILNER LTD, Shrewsbury *concrete plugs and muffs*
CHESTERFIELD TUBE CO LTD, Chesterfield *steel tubes*
THE CONSETT IRON CO LTD, Co Durham *steel plate*
THE DARLINGTON FORGE LTD, Darlington *large forgings*
DORMAN, LONG LTD, Middlesbrough *steelwork*
JAMES W. ELLIS & CO LTD, Newcastle *sectional buildings*
THOS. FIRTH & JOHN BROWN LTD, Sheffield *forgings, flanges and rolled steel rings*
JOHN FOLKES LTD, Stourbridge *forged bars*
GEO. GALLOWAY & CO LTD, Glasgow *bolts, etc*
W. GALLOWAY & CO LTD, Blaydon-on-Tyne *bolts, etc*
G. A. HARVEY & CO, London *dished ends*
WM. KENYON & SONS LTD, Dukinfield *insulation*
MACNAYS LTD, Middlesbrough *nuts, bolts, etc*
MOSS & GAMBLE BROS LTD, Sheffield *machined steel blocks*
MUREX WELDING PROCESSES LTD, Wa'tham Cross *electrodes*
PANTAK LTD, Slough *x-ray equipment*
RAINE & CO LTD, Newcastle *steelwork*
I. ROBSON & CO LTD, Stockton-on-Tees *nuts, bolts, etc*
ROSE, DOWNS & THOMPSON LTD, Hull *machining capacity*
SURREY TOOL DEVELOPMENT CO LTD, London *profile cutters*
THE UNIT SUPERHEATER & PIPE CO LTD, Swansea *standpipe assemblies*
VOKES GENSPRINGS LTD, Guildford *pipe supports*

STRACHAN & HENSHAW LTD

JOSEPH BOOTH & BROS, Leeds *overhead cranes*
BRITISH THOMSON-HOUSTON CO LTD, Rugby *electric motors and thrustors*
BROOKHIRST SWITCHGEAR LTD, Chester *limit switches*
DAVID BROWN INDUSTRIES LTD, Huddersfield *gears*
CRANE LTD, London *tank gauges*
ELLISTON, EVANS & JACKSON LTD, London *brake movements*
FLUIDRIVE ENGINEERING CO LTD, Isleworth *fluid coupling units*
J. S. FORSTER & CO LTD, Tipton *crane steelwork*
HARDY, SPICER LTD, Birmingham *couplings*
THE IGRANIC ELECTRIC CO LTD, Bedford *limit switches, control panels*
LANCASHIRE DYNAMO & CRYPTO LTD, Manchester *electric motors*
SKEFKO BALL BEARING CO LTD, Luton *bearings*
TALBOT STEAD TUBE CO LTD, Walsall *stainless steel tubes*
VARATIO-STRATELINE GEARS LTD, Slough *speed reducers*
JOSEPH WEBB & SONS LTD, Bury *steel forgings*
CHARLES WESTON & CO LTD, Manchester *oil seals*
HENRY WIGGINS & CO LTD, Birmingham *Nilo 40*
WORTHINGTON SIMPSON LTD, Newcastle *exhaust relief valves*

ALEX FINDLAY & CO LTD

THE BAIRD & SCOTTISH STEEL CO LTD, Glasgow *steelwork*
COLVILLES LTD, Glasgow *steelwork*
DORMAN, LONG LTD, Middlesbrough *steelwork*
THE LANARKSHIRE STEEL CO LTD, Motherwell *steelwork*
THE RIVET, BOLT & NUT CO LTD, Glasgow *nuts and bolts*
SHELTON IRON, STEEL & COAL CO LTD, Stoke-on-Trent *steelwork*
THE SOUTH DURHAM STEEL & IRON CO LTD, Middlesbrough *steelwork*
THE STEEL COMPANY OF SCOTLAND LTD, Glasgow *steelwork*

CLARKE, CHAPMAN & CO LTD

AIR CONDITIONING CORPORATION LTD, London *air-conditioning units*
APPLEBY-FRODINGHAM STEEL CO LTD, Scunthorpe *boiler drum nozzles*
B.K.L. ALLOYS LTD, Birmingham *boiler element bends*
BRITISH THOMSON-HOUSTON CO LTD, Rugby *crane motors*
BRITISH ROPES LTD, London *steel wire rope*
JOHN BROWN & CO LTD, Clydebank *bending drum plates*
BUTTERS BROS & CO LTD, Billingdon *derrick crane*
CHESTERFIELD TUBE CO LTD, Chesterfield *boiler header blanks*
CLYDE CRANE & BOOTH LTD, Gateshead *goliath crane erection, and permanent cranes*
CLYDE TUBE FORGINGS LTD, Glasgow *boiler element bends*
CONSOLIDATED PNEUMATIC TOOL CO, London *portable air compressor*
COPES REGULATORS LTD, London *boiler feed regulators*
DARHAM INDUSTRIES (LONDON) LTD, London *600-gallon road tank*
ERNEST DOE & SONS, Maldon *industrial tractor*
DORMAN, LONG & CO LTD, Middlesbrough *R.S. section*
ELLIOTT BROS (LONDON), LTD, London *instruments*
JAMES GORDON & CO LTD, Middlesex *boiler water level indicators*
HALLS BARTON ROPERY LTD, Hull *steel wire rope*
HAYWARD-TYLER & CO LTD, Luton *boiler circulating pumps*
HOLMAN BROS LTD, London *portable air compressor*
R. HOOD, HAGGIE & SONS LTD, Newcastle *steel wire rope*
HOPKINSONS LTD, Huddersfield *boiler mountings*
JARROW TUBE WORKS LTD, Jarrow *boiler tubing*
ALLAN KENNEDY & CO LTD, Stockton-on-Tees *open mesh flooring*
LANARKSHIRE STEEL CO LTD, Motherwell *boiler header ends*
CHAS. McNEIL LTD, Glasgow *drum manhole doors*
MARTIN, BLACK & CO LTD, Coatbridge *wire rope slings*
W. & E. MOORE LTD, London *wire rope slings, chains and shackles*
HERBERT MORRIS LTD, Loughborough *electric traversing gear*
MUDWELL & CO LTD, Leamington Spa *workshop building*
C. A. PARSONS & CO LTD, Newcastle *steam and feed piping*
SKINNINGROVE IRON CO LTD, Saltburn *R.S. sections*
SOUTH DURHAM STEEL & IRON CO LTD, Middlesbrough *durbar chequer plate*
THE STEEL COMPANY OF SCOTLAND LTD, Glasgow *steel boiler plates*
STEEL'S ENGINEERING PRODUCTS LTD, London *mobile cranes*
STEWARTS & LLOYDS LTD, Birmingham *handrail tubing*
TILGHMAN'S LTD, Altrincham *derusting plant*
UNIT SUPERHEATER & PIPE CO LTD, Swansea *boiler headers*
THE WELDLESS STEEL TUBE CO LTD, Wednesfield *boiler tubing*
W. C. YOUNGMAN LTD, Crawley *sectional timber buildings*

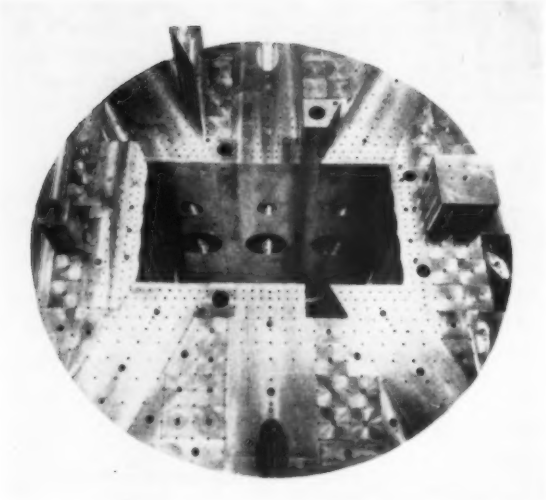
Concluded from last month's

NUCLEAR POWER—page 362

BERYLLIUM

G. L. MILLER, PhD, ARIC, MIChemE, MInstMM

Research Manager, Murex Ltd



Reflector area of the Idaho Materials Testing Reactor uses 600 lb of machined beryllium blocks

FABRICATION of beryllium is difficult. The metal in the cast condition has low ductility. Its cohesive strength at elevated temperatures is less than that of most common metals. While it can be deformed to some extent under compressive stresses it fails when subjected to tension and shear. The metal oxidizes readily when heated in air above 800°C and it has a strong tendency to gall or weld to steel tools. Extrusion is probably the most widely used and most successful method for forming beryllium.

Ingots for fabrication are prepared by vacuum melting beryllium in beryllia crucibles and bottom pouring into graphite moulds. The cooling of the cast ingots is regulated. If the cooling is too rapid the ingot will crack and if too slow a coarse grained structure is developed. The ingots are encased in low carbon steel and extruded in the temperature range 900° to 1100°C. More satisfactory results are claimed by using beryllium powder instead of cast ingots. The Brush Beryllium Co's method for preparing their special QMV powder is to comminute the vacuum cast ingots prepared by melting their pebbles. The ingots are turned on a lathe and the chips are milled in an atmosphere of dry nitrogen in a water-cooled beryllium-faced attrition mill.[11] Despite the precautions taken to avoid oxidation, the beryllium oxide content of the powder increases from 0·1 to 0·2 pct in the ingot to 0·3 pct in the chips and to about 0·7 to 1·0 pct in the final powder (minus 200 mesh). The presence of the beryllium oxide is advantageous in controlling grain size during sintering.

Consolidation of metal powder

The beryllium powder can be consolidated to full density by several methods but the one most used is vacuum hot pressing. This method has been employed to produce full density metal in the form of fine grained blocks several hundred pounds in weight. The moulds used are either steel or graphite. A pressure of 75-100 psi at 1050°-1150°C is applied for 4 to 20 hours. Higher pressures depending on the mould material can be applied and the time cycle reduced but this tends to produce metal with anisotropic mechanical properties. One of the main advantages claimed for the vacuum-hot pressing technique is the uniformity of properties in all directions.

A special process for consolidation which was developed at Massachusetts Institute of Technology[13] is claimed to give a metal with a ductility of up to 20 to 25 pct. A soft steel can is carefully packed with beryllium powder and then sealed. This billet is then heated and extruded at 900° to 1100°C. The sealed cans can also be rolled or forged to density employing the same pressure as for extrusion, i.e., 2,000 to 10,000 psi.

The first extrusion of cast ingots of beryllium yielded metal of zero ductility, but developments have resulted in the production of metal with considerable ductility. Rods having unidirectional ductility of the order of 20 pct elongation in tension can be produced by hot extrusion of cold compacted powders. Sheet having ductilities of the order of 30-40 pct elongation in all directions in the plane of the sheet (two-dimensional ductile) can be produced by hot extruding flats from cold-compacted powder followed by cross-rolling at temperatures of the order of those used for extrusion.

Impurities are not believed to be the cause of lack of ductility but important factors in the consideration of ductility at room temperature are preferred orientation and micro-structure.

Investigations indicate that improvements in ductility cannot be achieved by alloying with other metals.

The ductility which is achieved in the polycrystalline powder metallurgy grade of beryllium metal is closely related to grain size and it may be possible to improve the ductility of this type of metal by employing the knowledge that the oxide present tends to inhibit grain growth.

Importance of particle size

In general it is true to state that the finer the crystal size of the metal the better the ductility and as finer grained metal can be obtained by powder metallurgy this is the reason for the superiority of powder metallurgical products. The final particle size is determined by controlling the particle size of the powder and its oxygen content. the temperature and the sintering time. It might appear that the finer the initial powder the finer the crystal of the sintered metal but if the powder is too fine it tends to contain too much oxide and, in any case, it is well known in powder metallurgical processes that superfine particles sometimes produce a coarser final metal. The particle size distribution of the QMV powder produced by the Brush Beryllium Co is an optimum determined by experience to produce the desired qualities.

Data on ductility of commercial beryllium has been summarized as follows:[11]

1. A cast single crystal can slip extensively on $10\bar{1}0$ planes, twin on $10\bar{1}2$ planes, and fracture on $000\bar{1}$, $11\bar{2}0$ and $10\bar{1}2$ planes

2. Cast polycrystalline beryllium exhibits essentially zero elongation in tension at room temperature
3. Extruded castings have 2 to 3 pct elongation parallel to the extrusion axis and are brittle in a transverse direction
4. Hot-pressed 200 mesh powder has about 2 pct elongation in all directions
5. Extruded 200 mesh powder has 15 to 20 pct elongation in a parallel direction and 1 to 2 pct perpendicular thereto
6. Extruded 200 mesh powder cross rolled at 1000°C with 6 to 10 times reductions has 30 to 40 pct elongation in all directions in the plane of the sheet

All of these materials have essentially the same purity except that metal derived from castings has about 0·2 pct oxygen whereas metal made from powder has about 1 pct oxygen.

Corrosion resistance

The reactions of beryllium with oxygen, nitrogen and hydrogen have been studied.[17] The reaction with oxygen was studied over the temperature range 350° to 950°C. No coloured films were observed after two hours at 600°C. Above this temperature coloured oxides formed. The oxidation rate of beryllium compared favourably with zirconium, titanium and Nichrome V as shown in Figure 3.

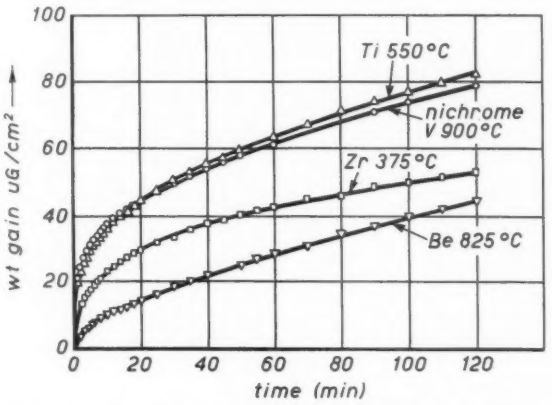


Fig 3 Compared with some metals beryllium has a lower oxidation rate at high temperatures

Coloured films were formed on beryllium after heating in nitrogen for two hours at 725°C and higher. No appreciable reaction between beryllium and hydrogen was found over the temperature range 300° to 780°C for a pressure of 2·3 cm Hg. Thermodynamic calculations showed that the oxide BeO and the nitride Be_3N_2 are stable over a temperature range of 0° to 1000°C *in vacuo* of 10^{-6} mm of Hg.

The corrosion of beryllium in water is sometimes erratic for reasons which are not always understood. Metal produced from hot pressed powder is much more consistent than cast metal. The rate of corrosion varies with the quality of the metal and the water. It is believed that impurities such as aluminium and silicon in the beryllium are harmful while iron is thought to be beneficial. Ions of chloride, sulphate, copper and iron in the water appear to increase the pitting rate.

Beryllium produced from hot pressed powder readily passes an acceptance test which involves exposure to water at 250°C for 96 hours. Some samples have been found to be more corrosion resistant than zirconium in water at 350°C but other samples disintegrate completely.[11]

There is no evidence of stress corrosion of beryllium in high temperature water. The corrosion resistance of beryllium in liquid metals is summarized in Table IV.[18]

Table IV
Resistance of beryllium to corrosion in various liquid metals under static, isothermal conditions

	temperature °C		
Liquid Metal	**300**	**600**	**800**
Bi	good	good	good
Bi-Pb	good	good	limited
Bi-Pb-Sn	good	good	unknown
Ga	good	limited	poor
Hg	pood	good	unknown
Li	good	good	poor
Na.K, or Na-K	good	good	limited
Pb	—	good	limited

Metallographic examination of beryllium samples tested in sodium at 540°C showed no stress corrosion or intergranular penetration.

Beryllium does not appear to be affected appreciably by neutron irradiation.[11] Specimens prepared from cast and forged metal, cast and extruded metal and extruded chips were exposed in a thermal reactor to an integrated flux of $1{\cdot}8 \times 10^{20}$ nvt and no change could be measured in dimensions, electrical resistivity or corrosion resistance and only a slight increase in hardness and decrease in thermal conductivity were observed.

Health hazards

Beryllium processing can entail a health hazard but industrial experience has shown that this can be substantially eliminated. No cases of poisoning due to ingestion of beryllium or its compounds have been reported neither has any case been reported in the handling of beryl ore or the mechanical working of low beryllium alloys. Soluble compounds of beryllium may cause dermatitis and the inhalation of mists, dust or fumes of beryllium compounds may cause acute pneumonitis. Medical authorities assert that mists, dust or fumes containing beryllium or its compounds may be instrumental in causing a delayed type of granulamatosis, named berylliosis, which develops relatively slowly, even over a period of several years. Certain individuals appear to be much more sensitive than others to the effects of beryllium.

Mr B. R. F. Kjellgren, President of the Brush Beryllium Co, in a recent paper[1] quoted statistics relating to the health of his company's employees. The figures showed that as soon as the health hazards were recognized and precautions taken remarkable improvements in the health of the operators were achieved. The results were achieved by suitable ventilating equipment, showers and clean clothing, training and supervision of the operators with constant checking on air samples in different parts of the plant combined with a medical examination of the employees at frequent intervals.

Applications and the future of beryllium

The use of beryllium in the atomic energy field as a material for moderators and reflectors is proven and an expansion of its use in nuclear applications may be safely predicted from the announcement in September 1956 that the US Atomic Energy Commission had awarded two contracts, each for 500,000 pounds of reactor grade beryllium metal, to the Brush Beryllium Co, and the Beryllium Corporation. The metal is to be supplied over a period of five years commencing January, 1958. The price on which the contracts were awarded is about $47 per pound of vacuum-cast beryllium ingot and it is expected that solid blocks of beryllium fabricated by powder metallurgy tech-

niques and ready for finished machining will be approximately $55 to $60 per pound.[1]

Sir Christopher Hinton recently stated[19] that the development of beryllium as a canning material still offers great problems, but he added, 'it does not seem probable that reactors using beryllium cans will be in operation until 1963, and that by that date we shall be achieving maximum can temperatures of about 500°C and gas outlet temperatures of about 425°C.'

Beryllium as a structural material

Recently there have been indications that beryllium has potential uses in structural applications. B. R. F. Kjellgren[1] has listed what he considers to be the potential structural properties of the metal:

1. Very high stiffness or rigidity (Modulus of elasticity is 40 pct higher than steel)
2. About the same coefficient of expansion as stainless steel. (Important property when steel and beryllium are used together)
3. Comparatively high heat conductivity (between aluminium and magnesium)
4. High melting point (1278°C) compared to magnesium (651°C) or aluminium (660°C)
5. Low density (practically equal to magnesium)
6. Excellent resistance to oxidation up to 825°C
7. Non-magnetic
8. High dimensional stability
9. In relation to its weight stronger in some respects than titanium, aluminium alloys and aircraft steels

It is considered that beryllium is a very promising structural material for aircraft and missiles. It is stated that the inherent lightness and strength of the metal may permit drastic reduction in airframe weight and afford considerable improvement in aircraft performance.[20,21]

Some of the advantages to be gained by the use of beryllium for transport planes are: (a) weight reduction of about 50 pct in comparison with aluminium alloy structure, (b) a range increase of about 40 pct and (c) estimated 'worth in use' to an operator might be as high as $1,000 per pound of beryllium used. Before these advantages can be achieved it is necessary to improve the ductility of the metal. It is remarkable that the high cost of the metal is not considered to be a serious deterrent.

Weight saving

Beryllium has been evaluated for aircraft[20,21] by the Rand Corp, Santa Monica, California (a non-profit organization conducting research for USAF) against 7178S-T6 aluminium alloy, 17-7PH steel, and 6A1-4Va titanium alloy on a weight basis for equal strength structures considering tension and compressive buckling loads over a range of temperatures. It is well known that the properties of beryllium metal vary a great deal depending on the method of production and on this evaluation the values taken are the highest obtained on extruded beryllium produced by the Brush Beryllium Co in 1955. These values are shown in Table V.[21] The analysis showed that a thin walled (sheet-stiffener) beryllium structure which would fail by buckling would weigh about 40 pct of a structure of conventional metals up to temperatures of about 538°C (1000°F).

It is claimed that with respect to tension and compression elements beryllium dominates the field of aircraft structural metals in affording lighter structures.

Oxide as a nuclear moderator

The use of beryllium oxide as a refractory is well known and its use as a moderator for nuclear reactors is reported to be as good as beryllium metal. It has the advantage that it is chemically inert, it has high heat conductivity and a high melting point, and it may well be a very suitable material for future use in high temperature gas-cooled reactors.

It should be noted that beryllium metal production is only a small part of the beryllium industry which is largely devoted to the production of beryllium-copper. It is the beryllium-copper industry which has largely subsidized the production of beryllium at a time when there was little or no demand for the metal. Even with the expansion of the production of pure beryllium it is expected that the beryllium-copper business operating simultaneously will influence future prices of beryllium metal.

Ductility all-important

The demand for beryllium and its alloys is steadily expanding and there is little doubt that the expansion will continue for some years to come.

Table V

Maximum properties obtained for beryllium (Brush Beryllium Co)

	modulus of elasticity	tensile strength 1000 psi	yield strength (0.2 per offset) 1000 psi	elongation (hot pressed) pct
70°F	44 × 10⁶	125	95	1–5
400°F	—	—	—	8–16
600°F	44 × 10⁶	85	65	—
800°F	—	—	—	16–34
1200°F	26 × 10⁶	31	20	10–14

The major deterrent to the application of beryllium is brittleness and none of the advantages of the metal can be utilized unless metal with improved ductility becomes available.

Data sheet on beryllium facing this page

References

1. B. R. F. Kjellgren, *Status of the Beryllium Industry in the USA*, Paper delivered to the Institute of Metals, London, March, 1957
2. G. L. Miller, *Beryllium and Zirconium*, The Times Review of Industry, April, 1956
3. Mineral Industry Surveys, US Dept. of the Interior, Bureau of Mines, Mineral Market Report MMS No. 2553
4. H. T. Reno, *Beryllium*, Bureau of Mines Minerals Yearbook, 1954
5. N. W. Bass, *The Rôle of Beryllium in Industry*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
6. P. S. Bryant, *Beryllium Production at Milford Haven*, Inst of Min & Met Symposium for the Extraction Metallurgy of some of the Less Common Metals, London, March, 1956
7. *Investigation of Beryllium Production in Germany and Italy, including production and uses of oxides and alloys*, BIOS Final Report No 550, Item No 21, HMSO, London, 1945
8. C. E. Windecker, *The Production of Beryllium by the Electrolysis of Beryllium Chloride*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
9. C. W. Schwenzfeier, jr, *The Sulphate Extraction of Beryllium from Beryl*, The Metal Beryllium, D. W. White, jr, and J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
10. L. J. Dereham, D. A. Temple, *The Preparation of Beryllium Metal by Thermal Reduction of the Fluoride*, Inst of Min & Met Symposium for the Extraction Metallurgy of some of the Less Common Metals, London, March, 1956
11. A. R. Kaufmann, B. R. F. Kjellgren, *Beryllium Technology*—USA, Peaceful Uses of Atomic Energy, Proceedings of the International Conference in Geneva, August, 1955, Vol 8
12. J. Williams, *The Powder Metallurgy of Beryllium*, Beryllium and Zirconium, Progress in Nuclear Energy, Series V, Metallurgy and Fuels Vol 1, Editors H. M. Finniston and J. T. Howe, 1956
13. P. Corzine, A. R. Kaufmann, *The Melting and Casting of Beryllium*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
14. D. W. Lille, *The Physical and Mechanical Properties of Beryllium Metal*, The Metal Beryllium, D. W. White, jr, and J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
15. B. R. F. Kjellgren, *Beryllium*, Rare Metals Handbook, C. A. Hampel, Editor, Rheinold Pubg Cpn, New York, 1954
16. W. W. Beaver *Fabrication of Beryllium by Powder Metallurgy*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
17. E. A. Gulbransen, K. F. Andrew, *The Kinetics of the Reactions of Beryllium with oxygen and nitrogen and the effect of oxide and nitride film on its vapour pressure*, Jnl Electrochem Soc, **97**, 11 (1950) 383
18. R. F. Koenig, *Corrosion of Beryllium in Liquid Metals*, The Metal Beryllium, D. W. White, jr, J. E. Burke, Editors, The American Society for Metals, Cleveland, 1955
19. *Reactor Design and Power Costs in the Future*, Sir Christopher Hinton, Atom No 6, April, 1957, UKAEA
20. L. Stone, *Beryllium offers High Structural Promise*, Aviation Week, December 17, 1956, p. 57
21. G. A. Hoffman, *Could Beryllium be used as a Structural Material?*, Materials & Methods, February, 1957, p. 100, Vol 45, No 2

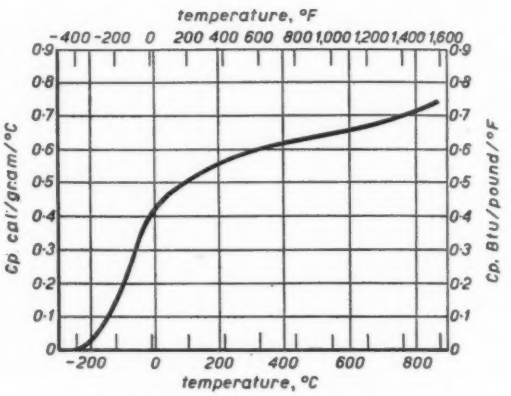
INTRODUCTION

Beryllium (Be) is the only light metal with a high melting point. It has a very low thermal neutron cross-section combined with the ability to moderate the velocity of neutrons. It is, therefore, of considerable interest to nuclear reactor designers particularly as it has also the advantage of being resistant to oxidation.

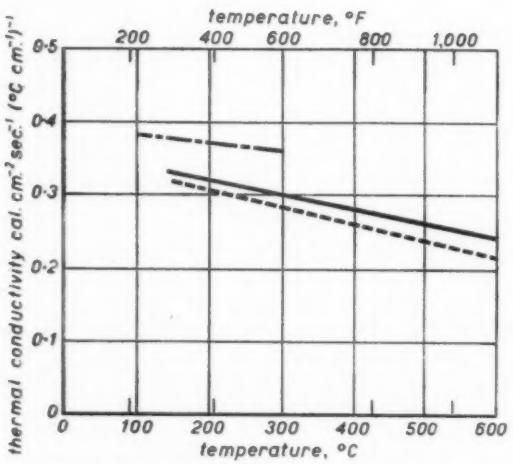
The main disadvantage is the difficulty of producing ductile metal. Much progress has been made in this field and with the effort that is being devoted, it is probable that the problem will be solved eventually. If ductile metal can be made available, it is possible that beryllium will find application as a structural material for aircraft and missiles.

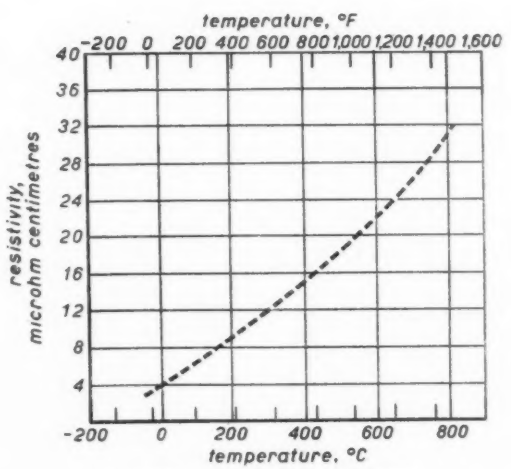
PHYSICAL PROPERTIES

atomic diameter: 2·221 Å
density: 1·85 g/cc
melting point: 1283°C
boiling point: 2970°C
vapour pressure: $\log P(\text{atm}) = 6{\cdot}186 + 1{\cdot}454 \times 10^{-4}T - 1670/T$
latent heat of fusion: 250/275 cal/g
thermal neutron cross section: 0·0090±0·0005 barns/atom
entropy (solid): 2·28±0·02 $S_{298{\cdot}1}$ cal/mol/°K
entropy (vapour): 32·56±0·01 $S_{298{\cdot}1}$ cal/mol/°K
electrical conductivity: 40% IACS
electrochemical equivalent: 0·04674 mg/coulomb
emissivity coefficient (solid) at 6500 Å: 0·61
emissivity coefficient (solid) at 5500 Å: 0·61
emissivity coefficient (liquid) to 2000°C at 6500 Å: 0·61
emissivity coefficient at 5500 Å: 0·81
reflectivity (white light): 50/55 pct
photoelectric work function: 3·92 eV
velocity of sound: 12600 m/s



Specific heat as function of temperature


temperature, °F
200 400 600 800 1,000
thermal conductivity cal. cm.⁻² sec.⁻¹ (°C cm.⁻¹)⁻¹
0 0·1 0·2 0·3 0·4 0·5
0 100 200 300 400 500 600
temperature, °C
Thermal conductivity as function of temperature



Resistivity as function of temperature

THERMAL EXPANSION (in. per in. per °C × 10^6) (ref. 14)

temp. range °C	Hidnert and Sweeney	Gordon (X-ray*)	transverse annealed, no 6	longitudinal annealed, no 4	transverse extruded, no 7 run no 1	transverse extruded, no 7 run no 2	longitudinal extruded, no 5 run no 1	longitudinal extruded, no 5 run no 2	longitudinal extruded, no 5 run no 3	mean coefficient
25–100	12·3	11·6	14·3	10·3	9·6	10·1	12·6	11·4	12·5	11·54
25–200	13·3	13·5	14·5	13·2	11·8	12·1	14·5	13·4	14·7	13·46
25–300	14·0	14·5	14·8	14·5	12·7	13·1	15·2	15·1	15·7	14·44
25–400	14·8	15·3	15·3	15·6	13·6	14·0	15·9	15·7	16·6	15·24
25–500	15·5	15·9	15·8	16·6	14·5	14·7	16·6	16·3	17·2	15·95
25–600	16·1	16·5					17·2	17·0		
25–700	16·8	17·0	(16·5)	(18·3)	(16·1)	(16·1)	17·6	17·5	(18·5)	17·23
25–800		17·4					18·1	17·9		
25–900		17·9					18·6	18·6		
25–1000		18·4	(17·5)	(20·4)	(18·0)	(17·6)	18·9	19·0	(20·0)	18·77

*Calculated from $(2a_{\perp} \pm a_{\parallel})/3$ for random orientation

Key to references may be found on page 449

MECHANICAL PROPERTIES

The mechanical properties of hot extruded flake and cast metal are shown below (ref. 15):

SOME ROOM TEMPERATURE DIRECTIONAL PROPERTIES OF EXTRUDED BERYLLIUM

material	condition	longitudinal to extrusion		transverse to extrusion	
		ultimate strength (psi)	elongation (pct)	ultimate strength (psi)	elongation (pct)
cast and extruded	as extruded	32 700	0·36	19 400	0·30
cast and extruded	annealed 800°C	40 000	1·82	16 600	0·18
extruded flake	as extruded	46 600	0·55	29 100	0·30
extruded flake	annealed 800°C	63 700	5·0	25 500	0·30

Material fabricated from powder has the best mechanical properties. The hot pressed metal is structurally isotropic while the mechanically deformed metal is anisotropic having appreciably better mechanical properties in the direction of working.

Pure beryllium does not undergo any known allotropic changes relative to temperature and the only method of heat treatment employed is to recrystallize the worked metal at 704° to 900°C. The effect of heat treatment is shown in table below (ref. 15):

EFFECT OF TEMPERATURE OF EXTRUSION AND HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF BERYLLIUM CASTINGS

extrusion temperature	as extruded and machined		as extruded, machined and annealed at 800°C (1472°F)	
	ultimate strength (psi)	elongation (pct)	ultimate strength (psi)	elongation (pct)
500°C (952°F)	73 100	0·28	51 600	3·30
700°C (1292°F)	60 200	0·30	47 600	2·74
900°C (1652°F)	44 500	0·45	45 100	2·47
1060°C (1948°F)	35 500	0·39	52 100	3·38
1208°C (2206°F)	34 800	0·44	50 200	3·80

The mechanical properties at elevated temperatures of fabricated beryllium made from flake (electrolytic) powder and cast ingots which have been hot extruded are shown in table below (ref. 15). The tensile elongation values are optimum at 400°C. The best transverse structural properties are obtained from extruded flake and powder.

EFFECT OF TEMPERATURE ON MECHANICAL PROPERTIES OF EXTRUDED BERYLLIUM

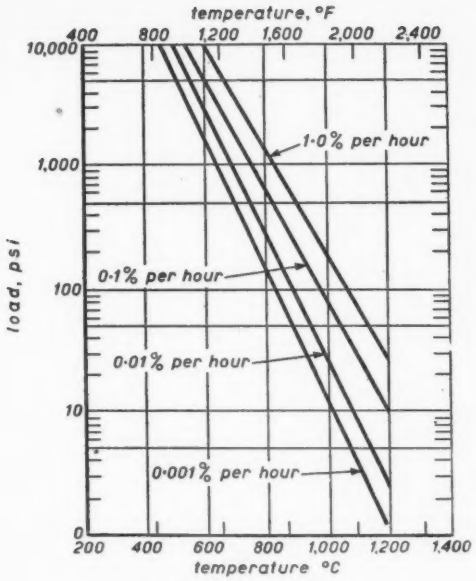
test temp.	condition	direction of test	flake		cast		powder	
			ultimate strength (psi)	elongation (pct)	ultimate strength (psi)	elongation (pct)	ultimate strength (psi)	elongation (pct)
room	as extruded	long.	46 600	0·55	32 700	0·36	85 000	16·0
		trans.	29 100	0·30	19 400	0·30	63 000	1·5
	annealed at 800°C (1472°F)	long.	63 700	5·0	40 000	1·82	—	—
		trans.	25 500	0·3	16 600	0·18	—	—
200°C (392°F)	as extruded	long.	—	—	39 900	13·2	62 000	23·5
		trans.	—	—	16 600	1·1	44 000	2·2
	annealed at 800°C (1472°F)	long.	—	—	37 900	13·4	—	—
		trans.	—	—	14 300	1·4	—	—
400°C (752°F)	as extruded	long.	36 600	14·8	27 700	29·0	43 000	29·0
		trans.	27 800	1·9	14 500	3·0	41 000	6·5
600°C (1112°F)	as extruded	long.	13 600	10·6	25 900	20·8	23 000	8·5
		trans.	11 200	2·5	16 000	1·2	22 500	4·5
800°C (1472°F)	as extruded	long.	4 800	9·1	9 300	25·6	5 200	10·5
		trans.	5 900	0·3	6 900	9·6	5 000	6·0

More detailed mechanical properties of beryllium are to be found in *The Metal Beryllium* (ref 14). This reference includes data for Poisson's ratio, creep and stress rupture. Poisson's ratio for beryllium is unusually low and shows considerable variation. The variation has been explained partially by the difference in Young's modulus measured in a single crystal, perpendicular to the basal planes and also parallel to the basal planes and an a-direction. The values obtained were:

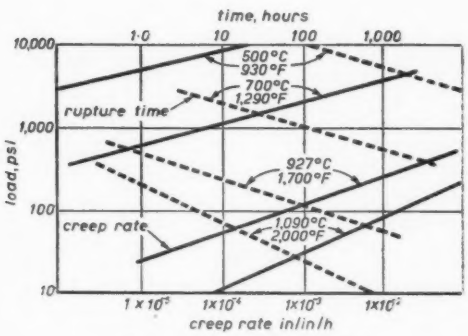
YOUNG'S MODULUS AND POISSON'S RATIO

	Young's modulus	Poisson's ratio
perpendicular	53 400 000 ± 1 700 000	0·10 ± 0·02
parallel	40 000 000 ± 2 000 000	0·035 ± 0·01

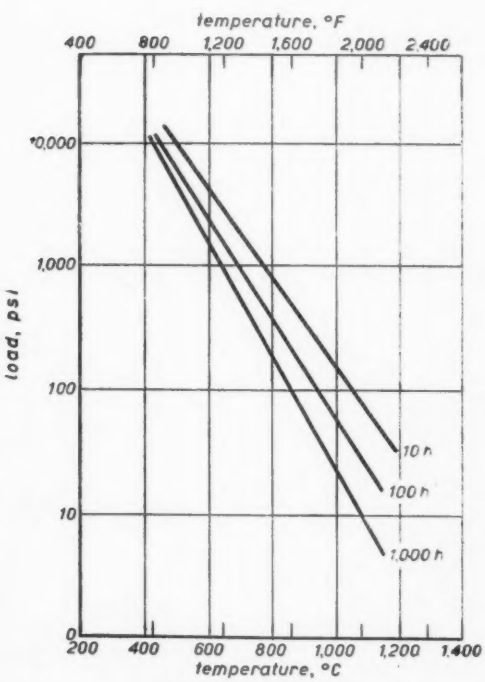
Creep and stress rupture data for vacuum cast and extruded metals are summarized in the figures following (ref. 16).



Load to produce creep



Stress rupture and creep data



Load to produce rupture

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING

DATA SHEET 5

Beryllium

physical and mechanical properties

Previous data sheets in this series

1 Microscopic cross sections of elements for thermal neutrons *May 1956 Vol I No 1*

2 Zirconium and Zircaloy II mechanical properties *June 1956 Vol I No 2*

3 Neutron diffusion formulae *July 1956 Vol I No 3*

4 Bessel functions *December 1956 Vol I No 8*

Copies of this data sheet may be obtained from

Nuclear Power, 3 Percy Street, London, W.1 6d post free

US reactors for Belgian group

Two Belgian firms—the Ateliers de Constructions Electriques de Charleroi (ACEC) and the S.A. Cockerill-Ougrée ironworks—have signed a licence agreement with the Westinghouse Electric International Company, which will permit them to manufacture and sell all non-military types of reactors developed by the American company. This is claimed to be a world premiere for licence agreements of such broad scope in the field of nuclear energy.

Valid for a period of fifteen years, the agreement grants to the licensees: An exclusive right to manufacture in Belgium all types of reactors developed by Westinghouse for land, marine or airborne purposes; a right to sell in all parts of the world, except the United States and Canada, the types of nuclear power stations and equipments designed by Westinghouse; all specifications and 'know how' for manufacturing processes and test procedures; the right not only to send staff on information missions to Westinghouse, but also to delegate to the latter a number of engineers for a period of 3 years during which time they will work with their American colleagues on the design and manufacturing works in progress.

It should be remarked that the agreement leaves ACEC and Cockerill-Ougrée free to take part in the manufacture of types of reactors other than those designed by Westinghouse.

Ready for Euratom

An International Products Division, with world-wide representation, has been formed by Thermotank Ltd, Helen Street, Glasgow, to handle sales and distribution.

Among the reasons for forming the division, say the company, must be counted the possibility of the European Common Market, and the greater opportunities which would then exist for the exchange of products throughout the continent.

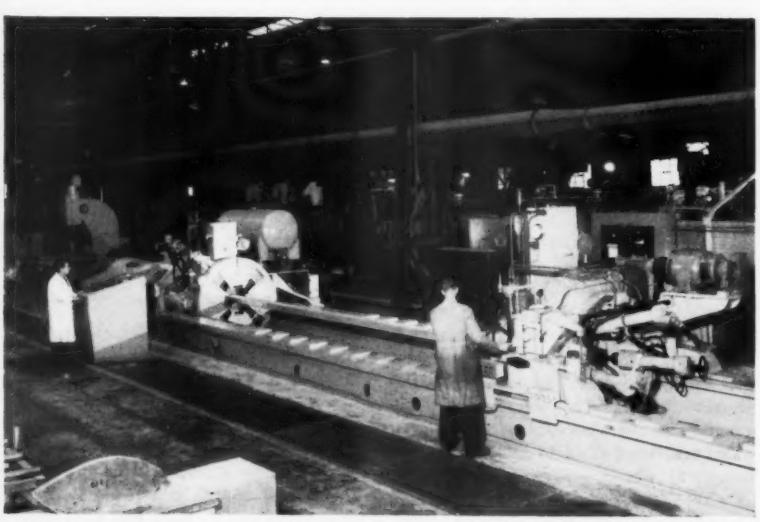
Crosby Valve extensions

In line with the policy adopted over the last few years, the Wembley factory of the Crosby Valve & Engineering Co Ltd is still expanding to meet the increased demands for production. In addition to recent expansions to the Machine Shop, Assembly Shop and Drawing Office another two-storey extension has recently been completed.

On the ground floor will be considerably increased assembly facilities, a complete duplicate test plant which will be used exclusively for customers' outside inspectors, thus releasing the present facilities entirely for production testing. On the first floor will be the assembly, setting and testing of Mason Neilan brass reducing valves and Crosby brass safety valves, also a completely new spares and repair department.

Work has just commenced on the addition of a third storey to the main office block.

New block at Crosby's Wembley factory includes spares and repair departments



Southern Forge have just installed this 250-ton stretching and detwisting machine at its Langley, Bucks, aluminium extrusion plant. Built by Fielding & Platt, it can handle sections up to 16 in. diameter and 45 feet long

No nuclear graphite yet

Contrary to press reports, Powell Duffryn Carbon Products has not embarked on the manufacture of nuclear graphite, nor does it intend to at present. This was stated by Sir Henry Wilson Smith, the chairman, in his annual report to the shareholders published recently. He said however his company had been appointed as a sub-contractor for graphite machining by The General Electric Company who are building the atomic power station for the South of Scotland Electricity Board at Hunterston, and he added that this machining work was likely to expand during the coming years. Although the company was doing certain research and development work on graphite its tangible participation in atomic energy work was still marginal and would take some time to develop.

Atomic film for Iron Curtain

Overseas distribution rights of *British Atomic News*, the first film of a series for the world promotion of British atomic products and services, devised, produced and directed by film-maker B. Charles-Dean, have been acquired by the Central Office of Information on the recommendation of the Board of Trade.

Due complete next June, this new headquarters for Honeywell Brown Ltd at Greenford, Middlesex, will include 483,000 cubic feet. It will accommodate all the administration of all divisions of the company—industrial instrumentation, thermostatic controls and microswitches. There will also be a training school. Managing Director E. C. Vorlander laid the foundation stone last month

There will be both English and foreign language versions.

Said Mr Charles-Dean: 'The film will go to Commonwealth and other overseas territories and in addition my organization will distribute the film to many Iron Curtain markets. We should not be content merely to parade our achievements in the field of peaceful atomic energy; we must go out and sell, and that is my whole object in producing this series of films—and the aim of the firms who are participating.'

British Atomic News—No. 1 runs for half an hour and is in *Eastmancolour*. Recently over 600 top industrialists in this country saw the film at the premiere held in London. It will next be seen at the Festival of Films in the Service of Industry at Harrogate, October 8-12.

Further productions in the series by British Atomic News Ltd, will also cover electronics, instrumentation and automation.

New Newcastle company

Formed recently, Charlton, Weddle & Co Ltd, Manor Works, Newcastle-on-Tyne, are to manufacture pipework for the marine and engineering industries.

The directors are R. Blackett Charlton, J. S. Weddle (managing), T. P. W. Matthews (technical) and A. Sherman (works). The Company Secretary will be Miss I. G. Taylor. It is planned to build a factory of 20,000 sq ft on a site at White Street, Walker. The company will fabricate all types of pipework and also intend to handle installation work. Valves and heating coils will also be made.

Hot materials handling

A. C. Wilson & Partners Ltd, specialists in the development, design and procurement of complete plants and equipment for laboratory testing, examination, processing and remote handling of irradiated nuclear fuels, have been invited by the Atomic Energy Authority to undertake a further series of projects. This work will be carried out at Design House under the direction of Mr J. A. Marsh, the Company's Chief Engineer (Mechanical and Chemical Division), head of the design and purchasing department handling nuclear projects.

Other projects being undertaken by this division of A. C. Wilson & Partners Ltd, in collaboration with the AEA, and due shortly for site commissioning include the following:

1. Irradiated Fuel Element Laboratory for Windscale
2. Experimental Loop Breakdown Cave for the Dounreay Materials Testing Reactor
3. Fuel Element Pond Facility for the Dounreay Chemical Plant. This was described in NUCLEAR POWER, August 1957
4. Blanket Stripping Cave—Fast Reactor Chemical Separation Plant, Dounreay

Steel plate suppliers

The Dohm Group, of Victoria Street, London, SW1, have announced that they can supply steel plates needed for super tankers, atomic power stations and high-pressure boilers. The Group has dealt with orders for plates up to twelve feet wide, and arrangements have just been completed whereby even greater widths to any specification, will be available. Normally, Dohm supply plates of up to 40 mm thickness, but they are now able to provide very thick plates on request.

In brief

Automatic control gear will be manufactured by Lee Guinness Ltd in a new factory at Newtownards, Co Down, N. Ireland. It will employ 400 to 500 workers. Lee Guinness transferred its entire works to Ulster in 1946. Managing Director A. H. Willetts said the new plant would produce a full range of automatic control gear of the type used in atomic power stations.

Data processing equipment from the Benson-Lehrer Corporation of Los Angeles is now being handled by a new British subsidiary—Benson-Lehrer (GB) Ltd of 12 Bargate, Southampton. It includes stripchart analysers, automatic graph plotters, electric typewriters and shaft coders.

Volume of business has grown so much that George Kent Ltd have converted their Belgian office into a separate company—Kent Continental SA, 82 Chaussée de Charleroi, Brussels. Full sales, engineering and service organization for all Kent products is available.

Larger premises have been taken by Thermotank Ltd for their London office —18 London Street, EC3 (telephone: Royal 7343). Phone number of Thermotank's works at West Drayton was changed to West Drayton 3685.

Branch office in Manchester has been set up by the Instrumentation Division of Costain-John Brown Ltd at 63 Brown Street, Manchester 2 (telephone: Blackfriars 5575). Area Instrument Engineer W. Brown can provide local service to supplement existing organization—controlled from London—for instrument installation and testing for process industries.

Official opening of new factory of Optica United Kingdom Ltd, Team Valley Trading Estate, Gateshead-on-Tyne 11, took place recently. A joint venture of Optica SpA of Milan and Joyce, Loebl & Co Ltd of Newcastle, the new company produces spectrographic equipment, industrial instruments and automatic controls. Joint managing directors are Herbert Loebl and R. H. Joyce.

London office at 16 Berkeley Street, W1 (tel: May 2779) under C. M. Powell was opened by BKL Alloys Ltd, King's Norton, Birmingham. Object is sales in London and Home Counties of BKL's *Tubend* welding fittings.

Changed telephone numbers of branch offices were reported by British Insulated Callender's Cables Ltd. Edinburgh is now Caledonian 6786: Swansea's numbers are now 52094 and 54403.

Registered as a private company—Hawker Siddeley John Brown Nuclear Construction. Capital is £500,000 in £1 shares, owned 50:50 by Hawker Siddeley and John Brown.

NAMES IN THE NEWS

H. M. Hobson Ltd announce that **Mr L. G. Carpenter** has been appointed to the board of the company. He remains managing director of Integral Ltd.

Mr R. F. Flack has been made sales manager for Measuring Instruments (Pullin), Ltd. He will be responsible for home and export sales. G. & J. Weir Ltd have appointed **Mr J. W. Atwell** assistant managing director of the executive board at Cathcart.

Mr G. Buchanan has been appointed assistant chief ship surveyor for Lloyd's Register of Shipping.

Sir David Eccles, President of the Board of Trade has been awarded an honorary fellowship of the British Institute of Management.

Mr A. M. A. Majendie and **Mr L. C. Harman** have been appointed to the board of Smiths Aircraft Instruments Ltd with effect from August 1.

Mr H. E. Cornish has joined British Telecommunications Research Ltd as general manager. He was previously Postmaster-General of Sarawak.

At a Honeywell-Brown dinner party recently tribute was paid by **Mr E. C. Vorlander,** managing director to **Mr V. D. MacLachlan,** sales director and general manager who was celebrating his twentieth year with the company.

Metropolitan-Vickers announce the following appointments. **Dr J. M. Dodds** becomes manager of the research department in succession to **Mr B. G. Churcher** who has resigned but will continue to act in an advisory capacity. **Mr P. O'B. Hove** has been appointed resident manager, Middle East of the Export Co. **Mr A. P. Mitchell** is appointed superintendent, erection department. **Mr H. C. Young,** formerly superintendent remains in the service of the company as consulting engineer.

Mr W. McLelland has been appointed area sales manager (Scotland and North East England) by APV-Paramount Ltd. In addition to his commercial activities, Mr McLelland will also act in an advisory capacity on technical matters.

OBITUARY

Dr R. W. Bailey, for many years in charge of research and then research consultant with Metropolitan-Vickers Electrical Co died on September 4. An outstanding figure in the field of research Dr Bailey served on many technical committees and was named as the inventor of eighty-eight British patents as well as publishing many technical papers.

The death occurred on September 2 of **Mr J. S. Redshaw.** He was a special director of Vickers-Armstrongs Ltd and had been naval architect to the company, before his retirement.

INSTITUTIONS

Data processing

The Society of Instrument Technology recently set up a section to cater for the current interest in data-processing systems. This section will begin to hold meetings in London this autumn and four papers are scheduled for the first session:—

October 10—*A System for Handling Wind-Tunnel Data,* by J. F. M. Scholes of RAE, Bedford.

November 14 — *A Digital Plotting Table,* by J. Morrison of Dobbie, McInnes Ltd.

January 28—*Digital Codes and Coding,* by M. P. Atkinson of NPL.

April 29—a joint meeting on *Scanning and Logging,* with papers by D. H. Whiting and J. Dunkley of ICI and J. Churchill of Sunvic Controls Ltd.

Initial emphasis will be on systems for handling experimental data, and for industrial monitoring and control. The section will be concerned with system design as well as with the detailed design of equipment; it will also deal with the use and organization of systems and with design-study work.

The literature on data-processing techniques and application is scattered and much existing knowledge remains unpublished; one of the section's first tasks will be to obtain papers that review the present stage of development.

Membership of the section is open to all members of the Society, who may also join the other special group, the Control Section. Further information from: the Secretary, S.I.T., 20 Queen Anne Street, London W1.

1958 BEAMA publicity conference

Following the great success of last year's British Electrical and Allied Manufacturers' Association Publicity Conference and the welcome given by delegates to suggestions for a further Conference in 1957, the BEAMA Publicity Committee has arranged it to be held at the Connaught Rooms, London, WC2, on Thursday, November 7 and Friday, November 8.

Speakers will include experts from outside the industry as well as members of the Electrical Manufacturing Industry. Subjects covered will be — 'Press Advertising at Home and Overseas'; 'Editorial Publicity and Press Relations'; 'The Compilation of Technical and Sales Literature'; 'Printing Techniques'; 'Exhibitions and their Practical Problems.'

The 'Hobby-Horse' session, in which delegates will have the opportunity of speaking on a subject of their own choice, will also be repeated. Mr D. G. Denoon, Publicity Manager (Public Relations), British Insulated Callender's Cables, Ltd, is the Conference Chairman. Names of the speakers and chairmen of individual sessions will be announced later. Attendance at the Conference will again be restricted to staffs of BEAMA member-firms. An informal dinner will be held for delegates to the Conference at the Dorchester Hotel on Thursday evening November 7.

Chemical engineering projects

The Council of The Institution of Chemical Engineers will support the Chemical and Petroleum Engineering Exhibition—Olympia, London, June 1958—by organizing a symposium on *The Organization of Chemical Engineering Projects.* The Symposium will take place at Olympia at the time of the Exhibition. Dates tentatively fixed are June 24 (afternoon session), June 25 (morning and afternoon sessions) and June 26 (morning session).

It is hoped that about fourteen papers will be presented.

Awards to radio men

The Clerk Maxwell premium of The British Institution of Radio Engineers has been awarded to Dr K. D. Froome, for his paper *Microwave Determinations of the Velocity of Light.* Dr. Froome is with the Metrology Division of the National Physical Laboratory. The Heinrich Hertz premium, for the most outstanding paper dealing with the mathematical or physical aspect of radio, goes to Dr A. G. Edwards for his paper *The Effects of Atmospherics on Tuned Circuits.* Dr Edwards is at present with the AEI Research Laboratories. The Marconi premium for the most outstanding engineering paper went to Professor P. M. Honnell for his paper *Prescribed-Function Vibration Generator.* Professor Honnell is in the Department of Electrical Engineering, Washington University, St Louis, USA.

Safety in chemical industry

The Society of Chemical Industry is to hold a symposium—*Safety in the Chemical Industry*—on October 14 and 15 at the Royal Institution, Albemarle Street,

London, W1. Proceedings will open at 2 p.m. with an address by Sir George Barnett, HM Chief Inspector of Factories. During the three sessions, ten papers will be presented, including one on handling radioactive substances by R. J. Sherwood, Health Physics Division, Harwell.

Non-members can attend and take part in the discussion for a fee of £2 2s. A dinner at the Connaught Rooms will be held on Monday, 14. Details: Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, SW1.

Courses at London college

Northampton College of Advanced Technology, St John Street, London, EC1, commences a course—*An Introduction to Nuclear Power*—on Friday, October 11, at 7 p.m. Forming the first year of a two-year course in nuclear power, the course comprises 20 lectures and is held on Friday evenings until March 14. The lecturers are mostly drawn from the college staff but there will also be visiting speakers from AEI Research Laboratories, The Radiological Protection Service and the GEC Atomic Energy Division. Fee for course is £2: full details from F. Y. Poynton, Head of Department of Applied Physics.

The second year of the 2-year course—*The Engineering Design of Nuclear Power Plant*—commences on October 15 at 7 p.m. and will be held on Tuesday evenings until March. Lecturers will be drawn from GEC Atomic Energy Division and Babcock & Wilcox Atomic Energy Department with a lecture on ship propulsion by H. Kay from the British Shipbuilding Research Association. Fee for this course is £1 10s.: details from J. C. Oakden, Head of Civil and Mechanical Engineering Department.

Enterprise 1958

The Scientific Instrument Manufacturers' Association is holding its Sixth Annual Convention at Eastbourne, October 24-27, 1957. Entitled *Enterprise 1958*, the event is mainly concerned with the commercial side of the industry and will consider the outward-looking topics of meeting the challenges of the future, especially that of the European free trade area.

The Marquess of Exeter (perhaps better known as Lord Burghley) will honour the Association by acting as the opening speaker. He has a particularly wide experience of business and industry and is Chairman of Cossor's, a firm of long-standing connexion with SIMA.

The four separate discussion panels of the Convention will be: European Free Trade—a Challenge; Presentation and Publicity; Methods and Materials for Tomorrow; Nucleonics.

The last panel, wholly devoted to the industrial uses, techniques and applications of nucleonic equipment is particularly noteworthy since for the first time a new branch of instrumentation is being made the subject of a complete Convention panel.

New HQ for Marine Engineers

Earl Mountbatten of Burma opened the new headquarters of the Institution of Marine Engineers on September 25. The new address is: The Memorial Building, 76 Mark Lane, London, EC3.

Refresher for plant engineers

Lord Sinclair, Chairman of The Imperial Tobacco Company is sponsoring the refresher course for senior works and plant engineers which is to be held at Bristol University this winter. Organized by the Education Committee of Incorporated Plant Engineers, in collaboration with leading industrialists and technical authorities, it comprises 19 weekly lectures on Tuesday evenings commencing October 15.

The course covers an extensive range of subjects, treated by specialists drawn in the main from industry. The fee is four guineas and copies of the syllabus and full particulars may be obtained from the Secretary to the Refresher Course, University Engineering Laboratories, University Walk, Bristol 8 (telephone 24161).

RESEARCH REPORTS

United Kingdom

*The following reports have been made available to the public by the United Kingdom Atomic Energy Authority. They may be borrowed or photocopies obtained from the Science Library, London, Department of Industrial and Forensic Science, Belfast, the Mitchell Library, Glasgow, and the Central Libraries at Acton, Birmingham, Bristol, Kingston-upon-Hull, Leeds, Liverpool, Manchester, Newcastle-upon-Tyne and Sheffield. They are also deposited in the Copyright Libraries (i.e. British Museum; University Library, Cambridge; Radcliffe Science Library, Oxford; National Library of Scotland, Edinburgh; National Library of Wales, Aberystwyth) and in the Patent Office Library. Reports marked * may be purchased from Her Majesty's Stationery Office.*

Reports are also available in the United States, from the USAEC depository libraries, a list of which will be found in NUCLEAR SCIENCE ABSTRACTS. Reports for sale may be purchased in the United States from: Sales Section, British Information Services, 30 Rockefeller Plaza, New York 20, N.Y.

AERE Harwell

Radiostrontinum fallout in biological material in Britain. *F. J. Bryant, A. C. Chamberlain, A. Morgan, G. S. Spicer* (May, 1957. 46 pp) AERE HP/R 2056 (with amendments) 7s*

Performance of a six position gridded ionization chamber for alpha energy measurements. *K. M. Glover* (Nov 1956. 19 pp) AERE C/R 2091 3s*

Theoretical thermal neutron flux distribution in empty channels in reactors. *D. A. Newmarch* (Dec 30, 1956. 28 pp) AERE R/R 2108 4s 3d*

The use of plasma waveguides as accelerating structures in linear accelerators. *L. B. Mullett* (Feb, 1957, 32 pp) AERE GP/R 2186 4s 9d*

The reaction between uranium hexafluoride and sulphuric acid. *D. Davies* (Feb, 1957. 4 pp) AERE C/M 300

Industrial Group

The determination of the total dissolved inorganic solids (excluding dissolved silica) in boiler waters (electrical conductivity measurement). (June 19, 1957. 4 pp) IGO-AM/W 95

The determination of uranium in aqueous and organic solvent solutions. (Polarographic method). (June 19, 1957. 7 pp) IGO-AM/W 97

The determination of total iron in natural, treated feed and boiler waters (thioglycollate method). (July 4, 1957. 5 pp) IGO-AM/W 98

The determination of dissolved iron in natural and treated waters (thioglycollate method). July 4. 1957. 5 pp) IGO-AM/W 99

Low temperature distillation of mixtures of corrosive halogen compounds. *P. L. Allen, J. F. Ellis* (April, 1957. 7 pp) IGR-R/CA 216

The modes of deformation leading to fracture of metals: a review of progress to January, 1957. *R. Doldon* (July, 1957. 13 pp) IGR-TN/C 569

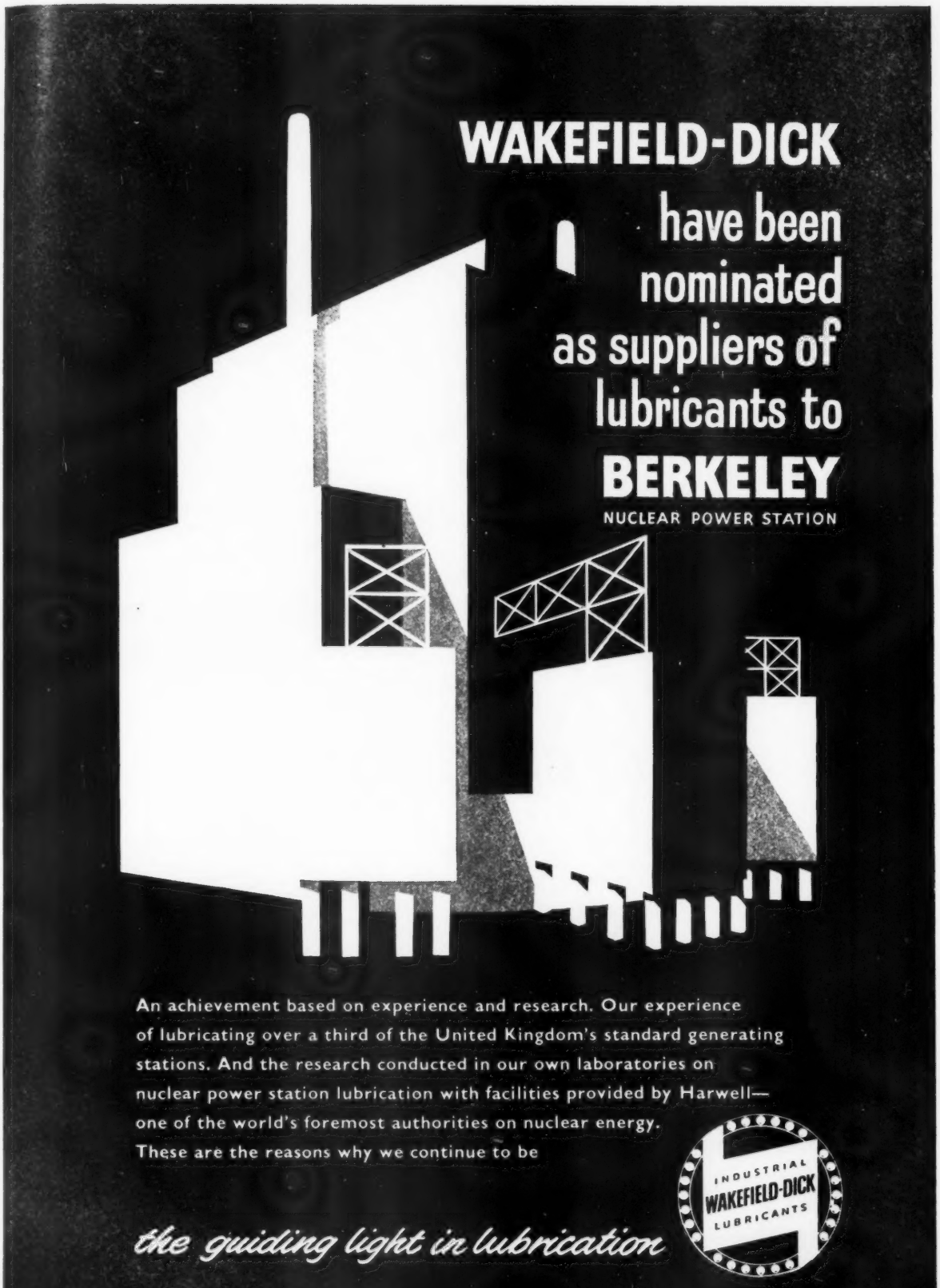
PROGRAMME

OCTOBER

FRIDAY 4
MANCHESTER IMechE Principles and applications of hydrodyamic-type gas bearings *G. W. K. Ford* et al 6.45 at the Engineers Club, Albert Square

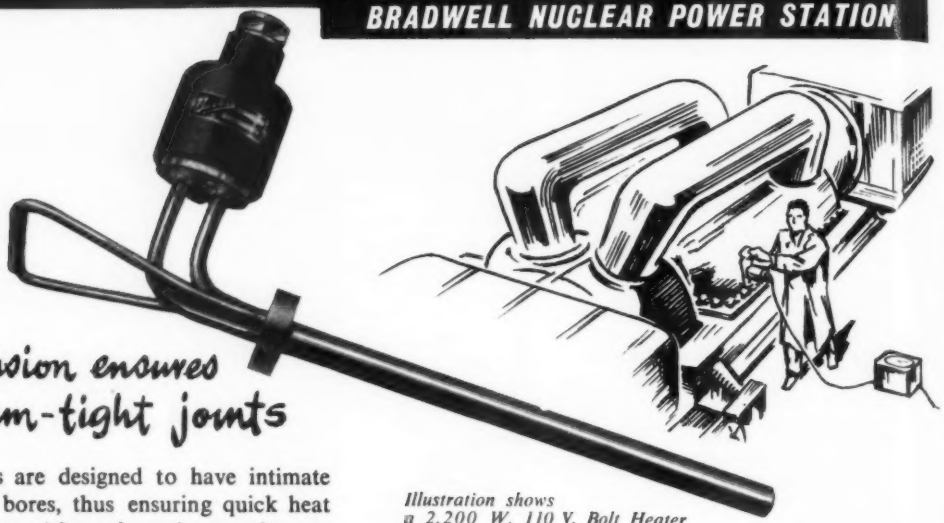
TUESDAY 8
SWANSEA IMechE Applications of radioisotopes to engineering *D. B. Smith* 6.00 at the South Wales Electricity Board's Lecture Theatre, Kingsway.

WEDNESDAY 23
PETERBOROUGH IMechE Applications of radioisotopes to engineering *C. G. Clayton* 7.30 at the Conference Room, CEA Generating Station


WAKEFIELD-DICK
have been
nominated
as suppliers of
lubricants to
BERKELEY
NUCLEAR POWER STATION
An achievement based on experience and research. Our experience of lubricating over a third of the United Kingdom's standard generating stations. And the research conducted in our own laboratories on nuclear power station lubrication with facilities provided by Harwell—one of the world's foremost authorities on nuclear energy. These are the reasons why we continue to be
the guiding light in lubrication
INDUSTRIAL
WAKEFIELD-DICK
LUBRICANTS
WAKEFIELD-DICK INDUSTRIAL OILS LTD

Backer elements

. . for the
BRADWELL NUCLEAR POWER STATION



Quick expansion ensures steam-tight joints

'Backer' Bolt Heaters are designed to have intimate contact with the bolt bores, thus ensuring quick heat transfer to the bolt only. After a few minutes adequate expansion is obtained to allow further tightening of the nut, which provides a truly steamtight joint as the bolt contracts. This is only one of the many ways in which 'Backer' elements are helping in the development of Nuclear Power Stations.

Illustration shows a 2,200 W. 110 V. Bolt Heater

BACKER ELECTRIC COMPANY LIMITED
ROTHERHAM YORKS

We look to the future . . .

The future of the peaceful use of nuclear power is limited only by the scope of man's ingenuity. We are proud to have supplied all the office and hostel furniture to the Nuclear Power Plant Co., Ltd. for the new Bradwell Power Station; a small, but essential contribution to a great project.

★ Our 94-page Office Equipment Catalogue is complete in every sense—fully illustrated and fully priced. It enjoys a national reputation as a problem-solver and specification reference.

Established 1848

For YOUR copy write NOW to

D. MATTHEWS & SON LTD.

61-63 DALE STREET, LIVERPOOL
TEL. CENtral 9851
The Largest Office Equipment Showroom in Gt. Britain
"FROM A PAPER CLIP TO A COMPLETE OFFICE"

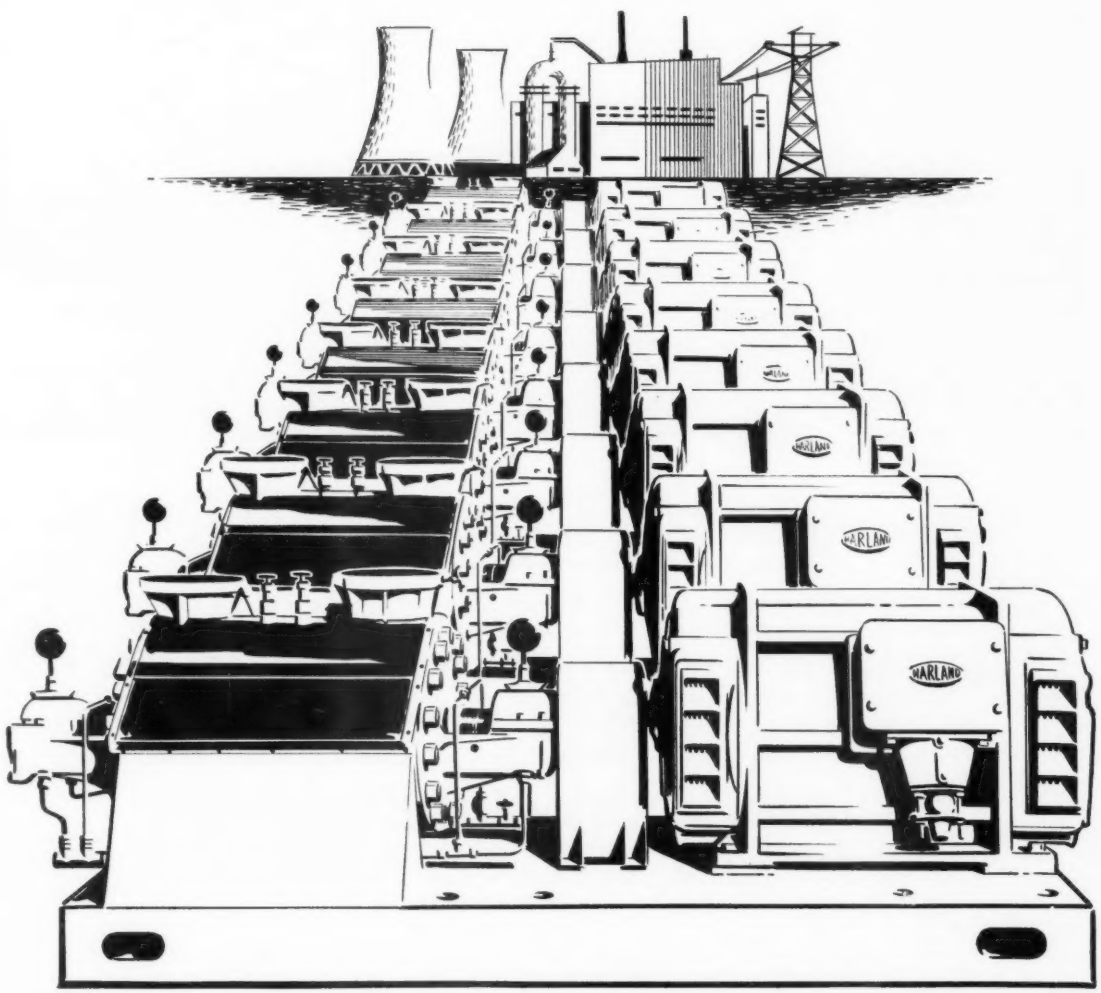
HARLAND

BOILER FEED PUMPS

at

Bradwell

On behalf of the Nuclear Power Plant Company, Messrs. C. A. Parsons have placed with Harland the contract for 10 groups of boiler feed pumps complete with motors for this major nuclear power station to be commissioned by the Central Electricity Authority within their first Nuclear Power programme.



THE HARLAND ENGINEERING CO LTD ALLOA SCOTLAND

LONDON & EXPORT SALES OFFICES: HARLAND HOUSE 23 PARK STREET W1

BRANCHES IN BRISTOL GLASGOW LEEDS NEWCASTLE NOTTINGHAM TIMPERLEY (Cheshire) WOLVERHAMPTON & Overseas

III

1837
120th ANNIVERSARY
1957

John Lenanton & Son Ltd.
supplied timber and shuttering plywood for
the construction of the Bradwell
Nuclear Power Station

JOHN LENANTON & SON LTD

BATSON'S & REGENT'S WHARVES · MILLWALL · LONDON · E.14
Telephone: EASt 1240

BAULK TIMBER, SHUTTERING TIMBER, DOUGLAS FIR AND BRITISH MADE SHUTTERING PLYWOOD FROM STOCK

HOLLIDAY HALL AND STINSON LTD.

ELECTRICAL ENGINEERS AND CONTRACTORS

DELTA HOUSE · BALHAM HIGH ROAD · LONDON S.W.12
Telephone: BALham 2411/6

COMPLETE ELECTRICAL INSTALLATIONS
E.H.T. and L.T. CABLING

Contractors to Government Departments.

Contracts undertaken at Home and Abroad.

RESPONSIBLE FOR ELECTRICAL INSTALLATION WORK FOR SITE QUARTERS ERECTED AT BRADWELL

TERRAPIN MULTIPLE MOBILE BUILDINGS

MAY 1957

The TERRAPIN part of the Bradwell story

Administrative offices and dormitory accommodation of 4,500 sq. feet, centrally heated, erected and occupied within 48 hours of commencement date.

Camp for 100 staff and 300 labour with administrative buildings including canteen, stores, sick bay, etc. totalling 38,500 sq. feet, all centrally heated, within 6 weeks of commencement date.

Main site offices for N.P.P.C. and C.E.A., site canteen and executives' residential quarters added, bringing total area supplied, delivered and erected complete with all internal services, including central heating from Terrapin Mobile Boiler Houses, to approximately 100,000 sq. feet of floor area in less than 6 months.

Telegrams:
TERRAPIN, WESDO, LONDON
Cables: **TERRAPIN, LONDON**
Telephone: **WELbeck 7996-7**

TERRAPIN LIMITED
6 PORTER STREET
BAKER STREET
LONDON W.1

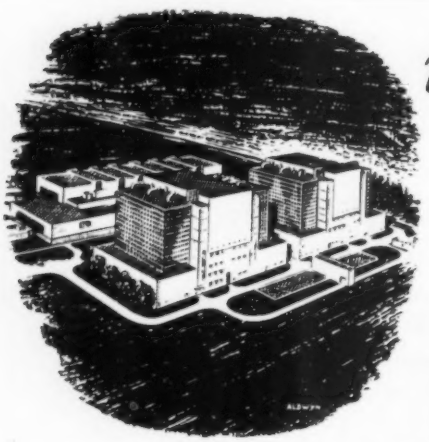
M.B. DREDGING CO., LTD.

DREDGED
CHANNEL OF TEMPORARY JETTY
AT
THE BRADWELL-ON-SEA NUCLEAR POWER STATION
FOR
SIR ROBERT McALPINE & SONS LTD.
(Member Company of The Nuclear Power Plant Co., Ltd.)

GRAB & SUCTION DREDGING CONTRACTORS
LAND RECLAMATION
DISPOSAL AREAS ON RIVERS THAMES & MEDWAY

M.B. DREDGING CO., LTD.

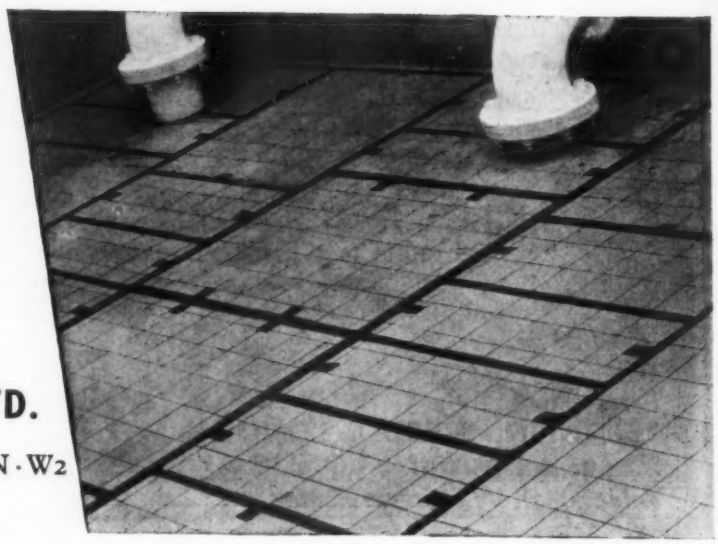
(Associated with Mears Bros. (Contractors) Ltd.)
154/8 Sydenham Road, London, S.E.26
Sydenham 5529



into the Nuclear age...

BROADS TRUCAST

CONTINUOUS DUCT AND ACCESS COVERS



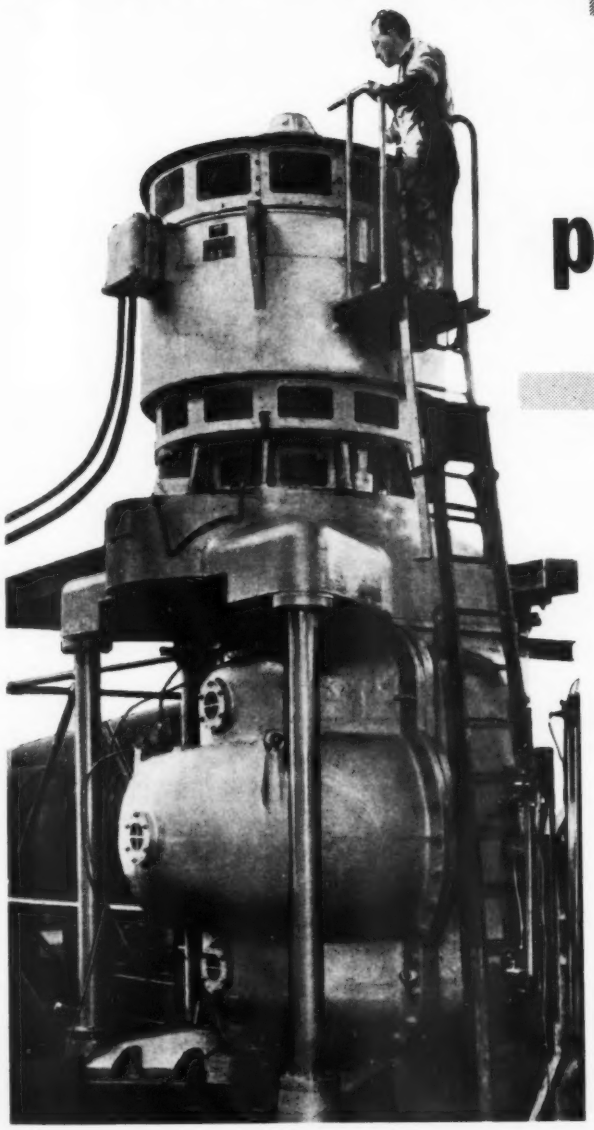
performing many duties in this specialised field

BROADS
MANUFACTURING CO. LTD.
4 SOUTH WHARF · PADDINGTON · W2
TEL: PADdington 7061 (20 lines)

THE BRADWELL STORY

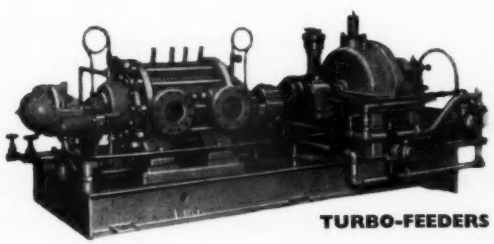
SIGMUND PUMPS

for nuclear power stations

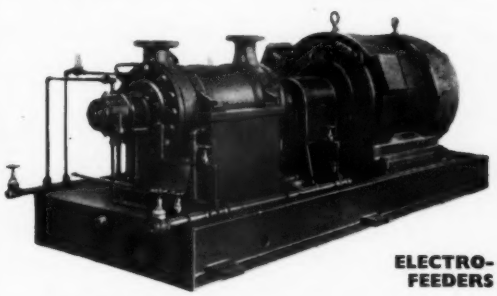


CIRCULATING WATER PUMPS
Horizontal and vertical units up to 50″ branch diameter.

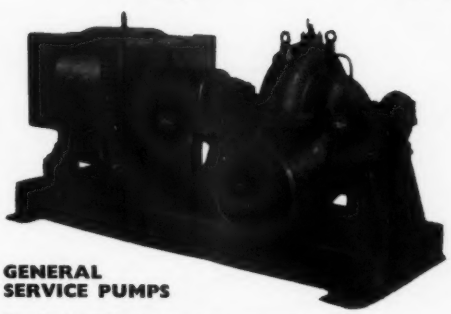
MODERN DESIGN—ANY CAPACITY
Precision built and exactingly tested by the latest scientific equipment.



TURBO-FEEDERS



ELECTRO-FEEDERS



GENERAL SERVICE PUMPS

Technical literature on request

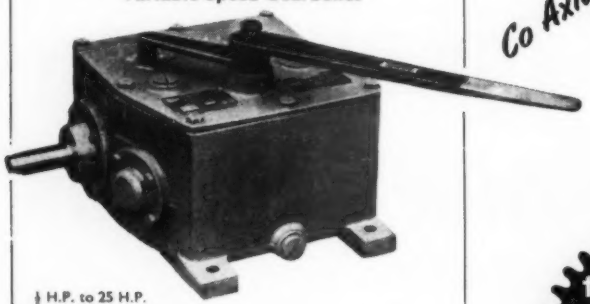
SIGMUND PUMPS LTD.

TEAM VALLEY, GATESHEAD 11, ENGLAND.

THE BRADWELL STORY

VARATIO & STRATELINE GEARS

VARATIO
Variable Speed Gearboxes



½ H.P. to 25 H.P.
Robust Construction
No Friction Drives
Positive Drive — Up to 26 Speed Changes
Gear change under load without clutch

Co Axial Shafts
Total Enclosure
Sturdy Compactness
High Efficiency

The Positive Answer to Your Drive Problems

We shall be pleased to supply Full Details on Application

STRATELINE
Fixed Reduction Speed Reducers

Torque range 46 lbs. ins. to 48,000 lbs. ins. Exact ratios to suit your requirements between 3 to 1 and 1,000,000 to 1. Motorised with any make or type of Motor or Non-Motorised. Positive drive in either direction. Reductions up 1,000,000 to 1 obtained in incredibly small space.

NON-STANDARD UNITS PRODUCED TO INDIVIDUAL REQUIREMENTS

VARATIO-STRATELINE GEARS LTD.,
278 Aberdeen Avenue, Trading Estate, Slough, Bucks
Telephone: SLOUGH 20271/2 *Telegrams: VARATIO, SLOUGH*

F. A. NORTON & SONS, LTD.

OF WICKFORD, ESSEX

PITS AT BRADWELL AND DANBURY

SUPPLIERS OF WASHED SAND AND AGGREGATES
TO BRITISH STANDARD SPECIFICATIONS FOR
SIR ROBERT McALPINE & SONS LTD.

"Yorkshire"

the name that is known
all over the world
for the highest quality
CONDENSER and HEAT EXCHANGER TUBES

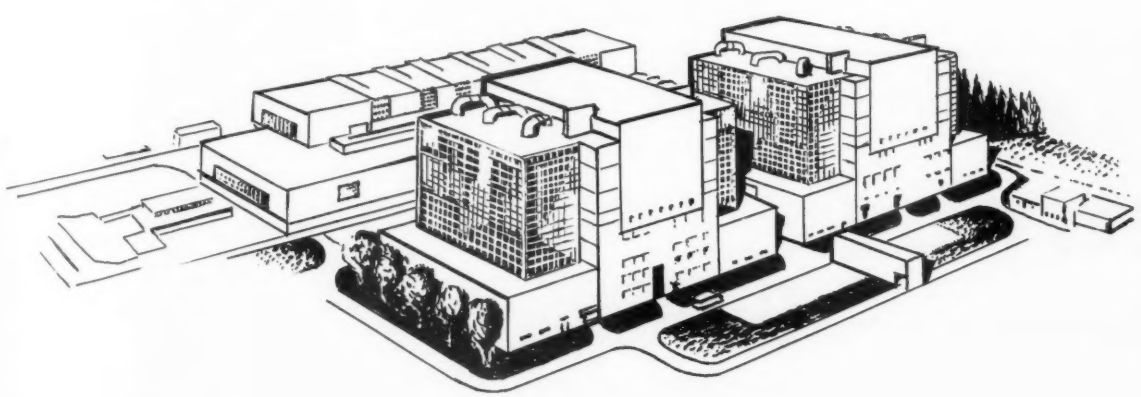
120 tons of main and dump condenser tubes
(also many other auxiliary tubes) were supplied
for the "A" and "B" Stations of the first
Nuclear Power Station at

CALDER HALL

and now **100 tons**
of "Yorcalbro" (aluminium-brass)
main condenser tubes will be fitted
in the Nuclear Power Station
under construction at

BRADWELL-ON-SEA

This advertisement appears
with acknowledgement to
The United Kingdom Atomic Energy Authority
and The Nuclear Power Plant Co. Ltd.



THE YORKSHIRE COPPER WORKS LTD. - LEEDS, ENGLAND · BARRHEAD, SCOTLAND

WELFORD GRAVELS LTD.

As suppliers of graded concrete aggregates to Sir Robert McAlpine & Sons Limited from a specially opened quarry near the site at Bradwell Atomic Station, we are proud that once again the mobility of our special plant and organisation is the complete answer for the smooth supply of materials so essential to costs and progress.

Where local supplies appear insufficient or unsuitable for efficiency of your contract, we shall be pleased to carry out a survey and install plant to serve your needs alone.

HEAD OFFICE:
GOLDINGTON
BEDFORD

4587/8/9

J. S. FORSTER
& CO. LTD.

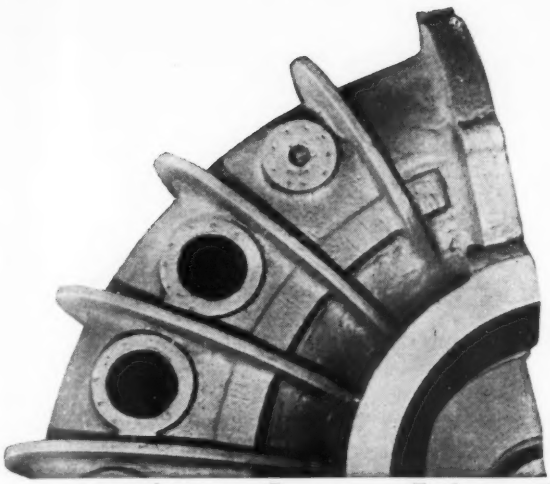
TIPTON, STAFFS

Suppliers of

STEELWORK

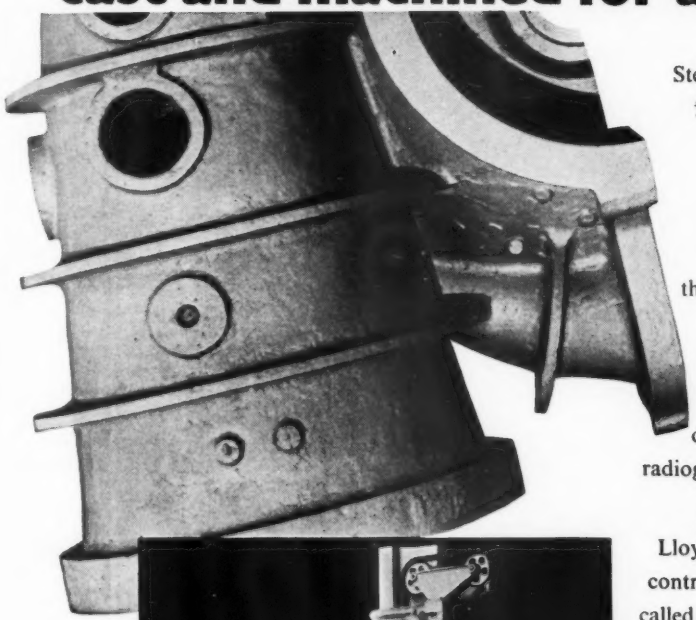
for the Travelling Gantry
for Strachan & Henshaw's
Charging and Discharging Fuel Machines at

BRADWELL
NUCLEAR POWER STATION



Half gas circulator casing cast in steel and machined for C. A. Parsons & Co. Ltd. for Nuclear Power Station, Bradwell. Weight as cast 35 tons. Sectional thickness max 7" min 1½". Reproduced by permission of C. A. Parson & Co. Ltd.

cast and machined for an important part

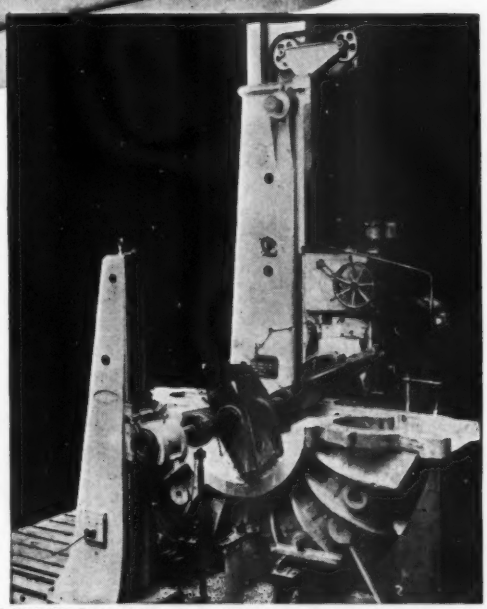


Steel castings are performing a number of important functions in the production of Nuclear Power, not least being the gas circulator casings cast for C. A. Parsons & Co. Ltd. reactors.

They form an integral part of the atomic pile, circulating as they do the carbon dioxide coolant through the reactor. Their dimensional accuracy and tolerances must be of a far higher standard than is usual in normal engineering practice.

The exacting nature of the service conditions also demands the most meticulous inspection, including radiographic examination and magnetic crack detection.

It is because of this need for flawless castings that Lloyds, with their unsurpassed facilities for scrupulous control at every stage of production and inspection, are called upon to cast and machine these vital components.



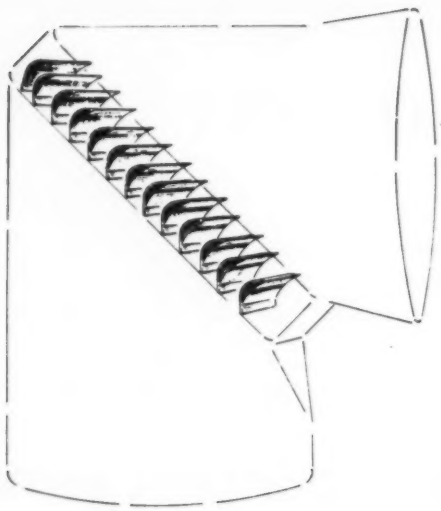
TYPICAL LLOYDS STEEL SPECIFICATION
used for general engineering requirements. Grade M. B.S 592, Grade B 0.30% carbon, Annealed, Yield Stress 16/19 t.s.i., Ult. Stress 32/37 t.s.i.; Elongation 30/20%; R.O.A. 40/25

LLOYDS

Britain's best equipped steel Foundry

F. H. LLOYD & CO. LTD., P. O. BOX No. 5, JAMES BRIDGE STEEL WORKS, WEDNESBURY, STAFFS. TELEPHONE JAMES BRIDGE 2401

A Print for Industry Ltd. advertisement



MANUFACTURERS OF

CASCADE VANES

TO LLOYD'S CLASS II REQUIREMENTS

To the order of:

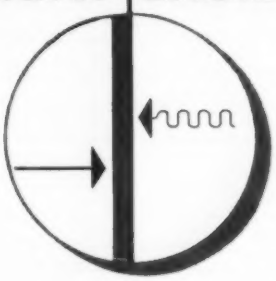
MESSRS. C. A. PARSONS & CO. LTD.,
FOR THE BRADWELL NUCLEAR POWER STATION

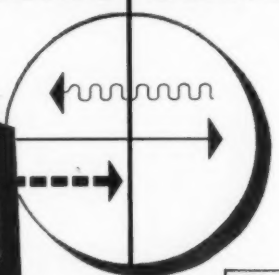
MODERN FACILITIES AVAILABLE FOR FABRICATIONS IN MILD STEEL, STAINLESS AND HEAT RESISTING MATERIALS AND NIMONIC

JOSEPH SANKEY & SONS, LTD.,
ALBERT STREET, BILSTON, STAFFS.
Telephone: Bilston 41161

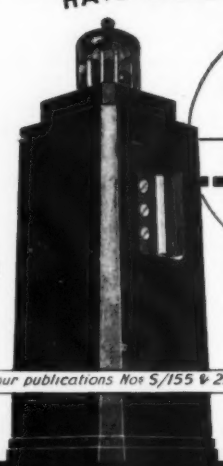
THE BRADWELL STORY

WHERE YOU NEED **HEAT EXCHANGE** YOU SHOULD HAVE **SLIME CONTROL**





THE MASTER CHLORINATOR



At Bradwell Nuclear Power Station, Wallace & Tiernan plant will be available to control marine growth in the circulating water system and prevent slime fouling in condensers.

We shall be glad to send you our publications Nos S/155 & 2208

WALLACE & TIERNAN LTD

SPECIALISTS IN CHLORINATION & ALL FORMS OF CHEMICAL FEEDING

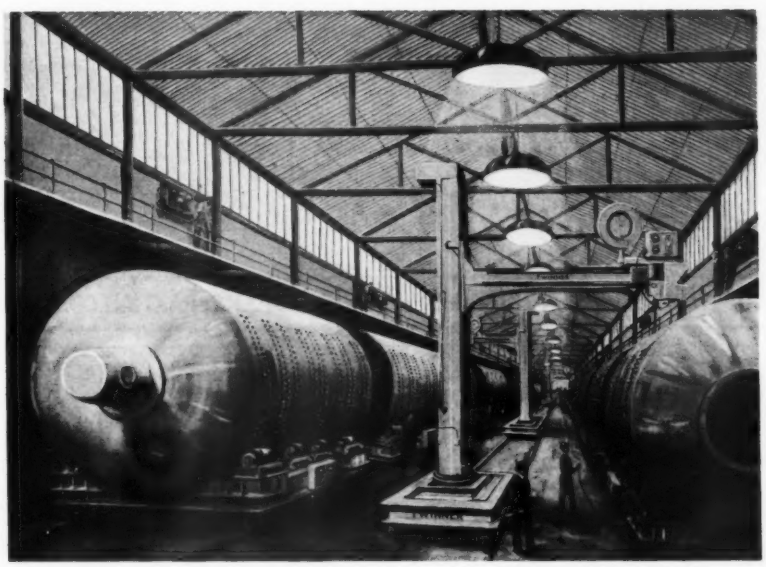
POWER ROAD · LONDON W4

TWINNER

POSITIONING EQUIPMENT

plays an important part in the construction of

BRADWELL NUCLEAR POWER STATION



An artist's impression of a Heat Exchanger Erection Shop, showing Twinner Self-Propelled Turning Rolls and Welding Head Manipulators

Specially designed manipulating plant required for lining-up, rotating and traversing the various sections of large Heat Exchangers during Welding, X-ray Inspection, Shotblasting and final Pressure Testing Operations is being Supplied by

Donald Ross *and Partners Ltd.*

TWINNER WORKS, GATWICK ROAD, CRAWLEY, SUSSEX *Telephone: CRAWLEY 25061/3. Cables: TWINNER, Crawley*

T 71.

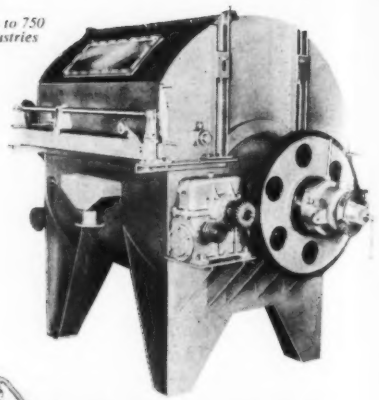
THE BRADWELL STORY

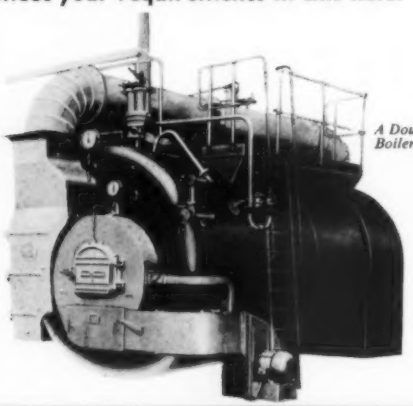
PAXMAN'S

SERVICE TO INDUSTRY

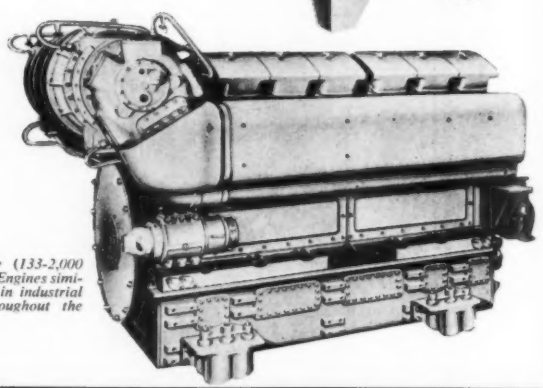
Paxman boilers and diesels are used in all industries for the supply of heat and power.
Paxman Rotary Vacuum Filters are supplied to an increasing number of industries for the continuous extraction of moisture from slurries and effluents.
Every new application of science to industry calls for new equipment, fabricated from steel or other metals. Paxmans have the equipment and the experience to enable them to meet your requirements in this field.

Rotary Vacuum Filter of up to 750 sq. ft. for the Chemical Industries





A Double Pass "Ultranomic" Boiler for steam generation.

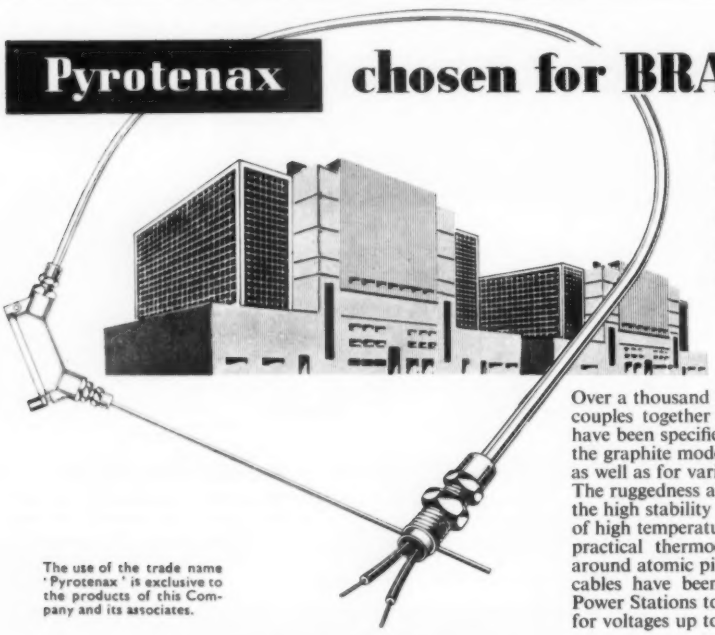


One of a range (133-2,000 b.h.p.) of Diesel Engines similar to those used in industrial locomotives throughout the world.

DAVEY, PAXMAN & CO. LTD COLCHESTER ENGLAND · TEL: 5151 · GRAMS: PAXMAN COLCHESTER · TELEX: 1875

G.6

Pyrotenax chosen for BRADWELL



The use of the trade name 'Pyrotenax' is exclusive to the products of this Company and its associates.

PYROTENAX M.I. Thermocouples and Compensating Cables have been chosen for Bradwell, one of the first Nuclear Power Stations commissioned by the Central Electricity Authority.

Over a thousand Pyrotenax mineral insulated metal sheathed Thermocouples together with considerable quantities of Compensating Cable, have been specified for temperature measurement of the fuel elements, the graphite moderator in the reactor and the concrete biological shield, as well as for various other ancillary applications.
The ruggedness and ductility of Pyrotenax thermocouples, together with the high stability of the magnesium oxide insulant under the influence of high temperatures and neutron bombardment, make them the only practical thermocouple for temperature measurement, both in and around atomic piles. Incidentally Pyrotenax M.I. copper covered power cables have been proved by long experience in conventional Steam Power Stations to be eminently suitable for power and control purposes for voltages up to 660 volt.

Write now for information sheet No. 42

Pyrotenax
COPPER COVERED MI CABLES
PERFECTED BY EXPERIENCE

PYROTENAX LIMITED

HEBBURN-ON-TYNE. Phone: HEBBURN 32244/7

Branches: LONDON · BIRMINGHAM · MANCHESTER · LEEDS · GLASGOW · CARDIFF

GD 42

GRUBB PARSONS

I R G A

Suppliers of gas analyser instruments for

the detection of water vapour in CO_2

and CO_2 in steam

also

infra red spectrometers

for

CALDER HALL "A"
CALDER HALL "B"
CHAPEL CROSS
DOUNREAY

Will now make their instrumentation contribution

to

BRADWELL

SIR HOWARD GRUBB PARSONS & COMPANY LIMITED
WALKERGATE NEWCASTLE UPON TYNE 6
Subsidiary of C. A. PARSONS & COMPANY LTD

THE BRADWELL STORY

W. H. SMITH & CO. ELEC. ENG. LTD.

12 YORK STREET
MANCHESTER, 2
CENTRAL 2991—SIX LINES

MAIN
ELECTRICAL CONTRACTORS
FOR
N.P.P.C.

ARE PROVIDING A PARAGRAPH IN EVERY CHAPTER
OF

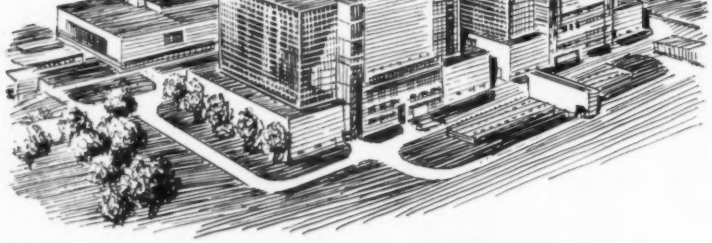
"THE BRADWELL STORY"

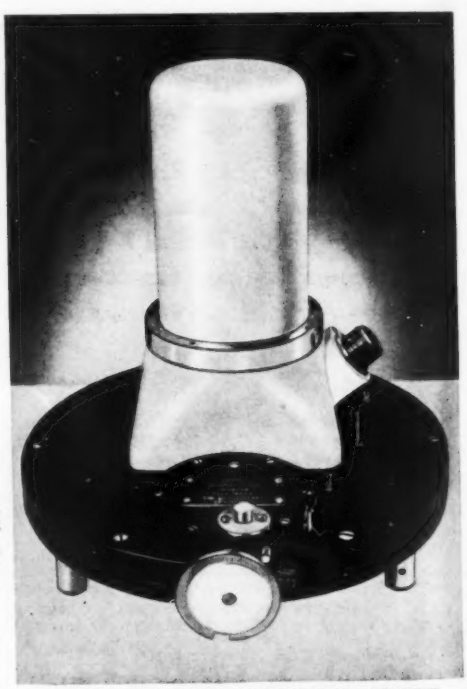
Here, there, or anywhere...

Here at Bradwell, and wherever the need arises, this new Mervyn instrument will provide essential information. Designed for the alpha assay of materials near Nuclear Reactors, the LARGE AREA SCINTILLATION COUNTER can be conveniently installed in a jeep or similar vehicle.

Features are:

- Designed especially for samples of low activity.
- Over *twice* the scanned area of any other similar instrument.
- Interlocked shutter to prevent accidental unmasking of phosphor.
- 3 inch diameter sample holder.
- Robustly engineered for field use.
- Low background count rate.





LARGE AREA ALPHA SCINTILLATION COUNTER
(Type 1483A)
as supplied to the Central Electricity Research Laboratories for use at Bradwell.

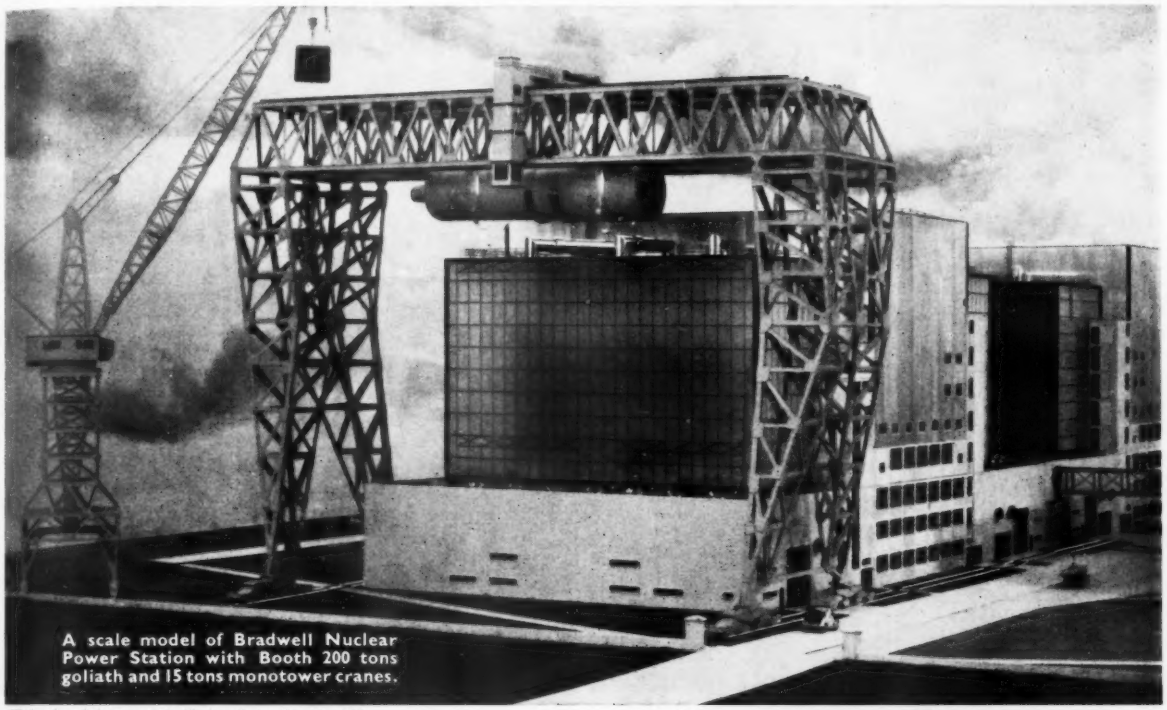
MERVYN INSTRUMENTS ST. JOHNS, WOKING, SURREY · WOKING 5200

PB13

THE BRADWELL STORY

Britains biggest Crane ..

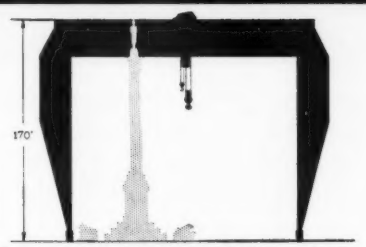
200 TONS GOLIATH FOR BRADWELL



A scale model of Bradwell Nuclear Power Station with Booth 200 tons goliath and 15 tons monotower cranes.

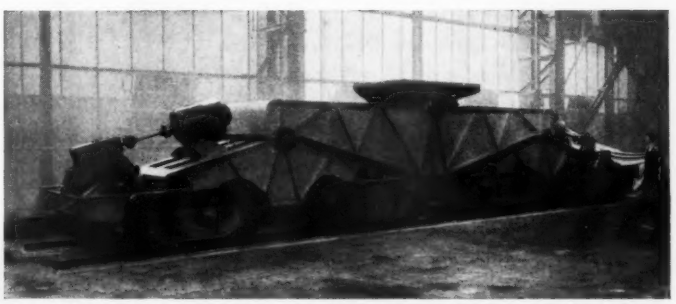
With acknowledgement to the Nuclear Power Plant Co. Ltd.

In crane makers' parlance a goliath crane is usually any crane of the overhead girder type supported by legs carried on travelling runners but the Booth Goliath Crane which is being built for Bradwell Nuclear Power Station fulfills every impression of magnitude which the word conveys. As shown in the illustration the crane will completely straddle the main part of the station, the massive buildings containing the nuclear reactors and heat exchangers, the bogies running on railway tracks on either side.



The Booth Goliath showing Nelson's Column on the same scale.

The crane is now being erected on site and on completion its duties will be to handle all materials and units involved in building the station. A 30 tons auxiliary hoist is provided for the smaller lifts but single items of equipment weighing up to 200 tons can be lifted on the main hoist and placed with precision in the position required.



One of the four sixteen-wheel standard railway gauge bogies in the Booth works.

CLYDE BOOTH

CLYDE CRANE & BOOTH LTD.

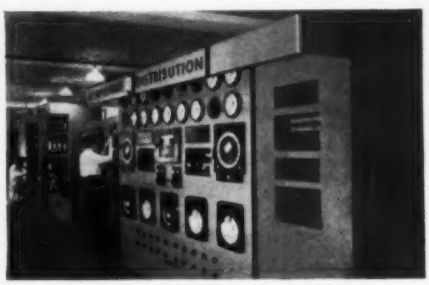
Incorporating :

Joseph Booth & Bros.,
Union Crane Works, RODLEY, Leeds.
Telephone : Pudsey 3168 (6 lines). Telegrams : "Cranes," Rodley.

Clyde Crane & Engineering Co.,
MOSSEND, Lanarkshire.
Telephone : Holytown 412 (6 lines). Telegrams : "Clyde," Motherwell.

CONTROL AND INSTRUMENT PANELS

Thermocontrol desk, cubicle and wallmounting panels (including illuminated graphic panels) are designed and fabricated to customer's requirements in steel, plastic or specified materials. These panels have a coded wiring system of ample capacity, and programme, alarm and monitoring pilots are included. Liquid lines are provided with suitable drip trays. All panels are functionally tested before despatch.



These Power Stations use Thermocontrol Panels

C.E.A. Roosecote Sets 1, 2, 3 & 4
C.E.A. Bold (St. Helens) Sets 1, 2, 3 & 4
C.E.A. Plymouth "B" Set 3
C.E.A. Battersea "B" Sets 1, 2, 5 & 6
Nova Scotia Light & Power Co. Halifax. Sets 4 & 5
Wilge, South Africa Sets 1 & 2
Elektrim, Poland
Ywana Power Station, Burma
and many others at home and overseas.

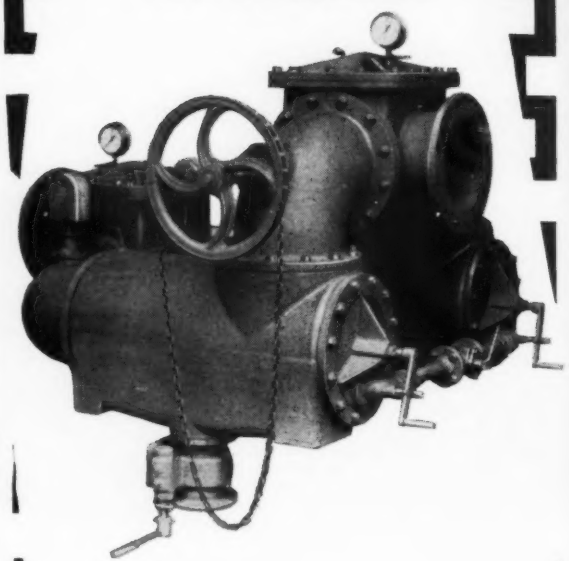
Twenty-one years of experience in heating and ventilating gives us a right to blow our own trumpet! We offer you an unparalleled service, the best equipment—and the knowledge that if it's a Thermocontrol installation, it'll do its job well and thoroughly. For details of this, or any other equipment which we make, write to:—

Thermocontrol INST. CO. LTD.

2-8 VALENTINE PLACE, BLACKFRIARS ROAD, LONDON, S.E.1

Thermocontrol manufacture a complete range of controls for air conditioning, refrigeration, automatic temperature and humidity adjustment in process controls for automation.

fifteen BRACKETT TWIN STRAINERS for Bradwell

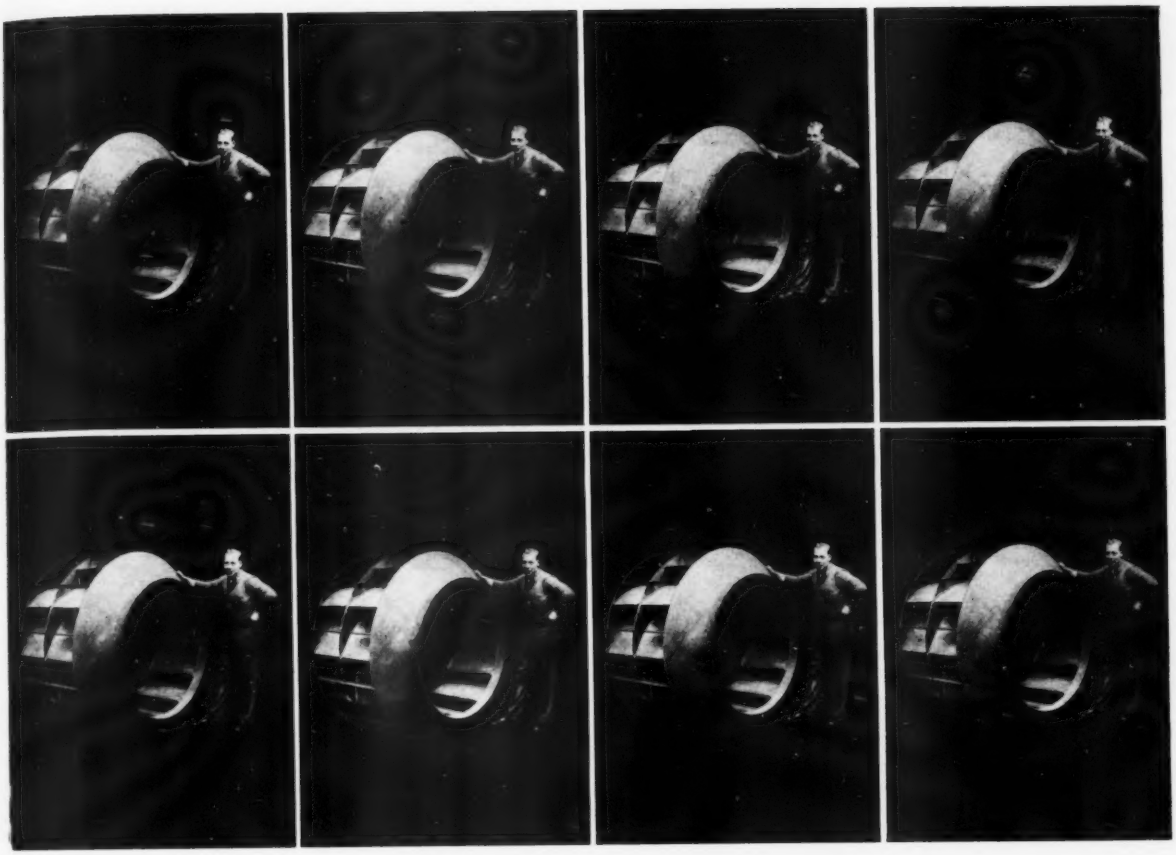


Cooling water at Bradwell nuclear power station will be strained by Brackett Twin Strainers. Only one of the pair is in use at a time and an instantaneous change from the dirty to the clean basket can be made without interruption to the water flow. By operating one valve, water is diverted to a clean basket. The dirty strainer is not removed for cleansing but is thoroughly washed *in situ* by flushing water, and the sludge drained away through a valve. To obviate the necessity for frequent cleaning, the straining baskets have a waterway area which is greatly in excess of the pipe area to which the strainers are connected. Brackett Strainers can be used in Suction or Delivery pipelines, and are indispensable where a continuous supply of strained liquid is required.

F W BRACKETT & CO LTD
COLCHESTER

PHONE: COLCHESTER 3958

P.553



Reactor Shield Cooling

"Everything of the best" is the keyword in the construction of a nuclear power station, and this extends down to the smallest detail of equipment.

As one of the specialised sub-contractors called upon by the Nuclear Power Plant Company Limited at Bradwell to provide of their best for this important project, we have been pleased that our 75 years in fan engineering, coupled with our modern research, testing and manufacturing resources, have once again brought recognition of the fact that

You can depend on "Sirocco"

Our contribution to the Bradwell Story is eight 68-ins. diameter double inlet "Sirocco" Backward Aerofoil Bladed Fans for reactor shield cooling, each capable of handling 108,000 c.f.m. at 5 ins. W.G.

"Sirocco" products in the field of nuclear power also include:

DUST COLLECTORS · AIR CONDITIONING AND VENTILATING OF LABORATORIES · GAS CIRCULATING PLANT · FUEL ELEMENT COOLING FANS · CIRCULATORS FOR HEAT TRANSFER RIGS · FANS FOR EXHAUSTING FROM GLOVE BOXES AND FUME CUPBOARDS

Our Nuclear Power Department is at your service

SIROCCO — DAVIDSON & CO. LTD. — BELFAST N. IRELAND

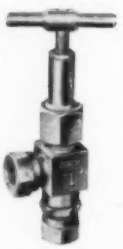
SIROCCO ENGINEERING WORKS,
BELFAST, NORTHERN IRELAND.

London · Manchester · Glasgow · Birmingham · Newcastle-on-Tyne · Leeds · Cardiff

THE BRADWELL STORY

ERMETO AT BRADWELL

The British Ermeto Corporation is happy that the products of its Maidenhead factory have again been employed on a nuclear project of such national importance as the new Bradwell station.
For many years the Corporation has been engaged, in association with nuclear engineers, in developing a range of special valves for use on reactors and auxiliary services.



ERMETO

VALVES & COUPLINGS
BRITISH ERMETO CORPORATION LTD.,
MAIDENHEAD, BERKS.

OIL SEAL DIFFERENTIAL
PRESSURE CONTROL VALVES

FOR

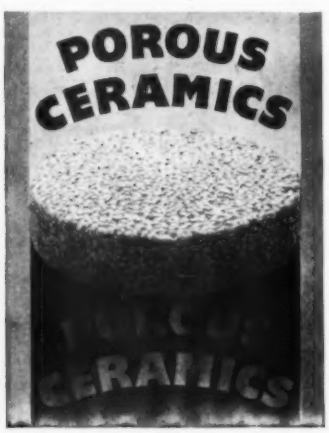
BRADWELL-ON-SEA
NUCLEAR POWER STATION

MADE BY

BLAGDON ENGINEERING Co. Ltd.
BLAGDON, SEATON BURN,
NORTHUMBERLAND

PRECISION ENGINEERS, SPECIALISTS IN EXPERIMENTAL AND DEVELOPMENT PROJECTS

for the Cleaning of Gases



Chosen for BRADWELL by the N.P.P.C., Royal Doulton Corundum Grade Porous Ceramics offer:

High Permeability	—	$\Delta p = K.F^{1+n}.S^{n}.\mu^{1-n}.(\rho/S)^{n}$
High Efficiency	—	approaching 100% at a particle size of 10 microns.
Inertness	—	high alumina, minimum bond and high firing temperature.
Thermal Stability	—	at elevated temperatures, with excellent resistance to thermal shock.
High Mechanical Strength	—	and resistance to abrasion.

Write for further information to:

DOULTON INDUSTRIAL PORCELAINS LIMITED
Dept. NP, Royal Doulton Potteries, Wilnecote, Tamworth, Staffs.

HEWELL SPRINGS

for the Bradwell Nuclear Power Station

HEWELL SPRINGS

for your products

HEWELL SPRING CO. LTD.
REDDITCH · ENGLAND

"GR"

GENERAL RADIOLOGICAL LIMITED

are happy to announce that they have been asked by Messrs. C. A. Parsons Ltd., to supply the complete neutron flux monitoring system for the reactor which the Nuclear Power Plant Company are constructing at:

Bradwell-on-Sea

The range of Reactor Monitoring Equipment available includes:

- Linear Ratemeters
- Logarithmic Ratemeters
- Scalers
- Discriminators
- Multirange D.C. Linear Amplifiers
- Pulse Amplifiers
- Shut Down Amplifiers
- Power Deviation Meters
- Ion Chamber H.T. Supplies
- Counter H.T. Supplies
- Pulse Counters
- Neutron Sensitive Ion Chambers
- Annular Ion Chambers for Flux Plotting

Complete pulse counting, logarithmic and linear channels.

Among the other items to be supplied to Bradwell will be the Ion Chamber withdrawing mechanisms.

GENERAL RADIOLOGICAL LIMITED

15-18 Clipstone Street, Great Portland St. London W.1

Telephone: MUSeum 3121

THE POWER BEHIND THE POWER

In the new field of nuclear engineering, as in older techniques, lifting equipment plays an important part. This Company, with experience gained over many years in the design and development of special-purpose lifting gear, is ready to meet the demands, trends and conceptions occasioned by the new science.

This 10-ton Diesel-engined Winch was designed and built for an eminent civil-engineering firm engaged on highly technical work

13-31 Poplar High St., London, E.14

W. & E. MOORE LTD.

Specialists in Lifting Equipment

East 2613-7
,, 4601-2

Established 1863

Self-cleaning
ROTARY WATER STRAINERS
for Bradwell
will be supplied by
HICK HARGREAVES

The design and construction of the new station has been entrusted to *Nuclear Power Plant Co. Ltd.* with whom we are proud to be associated as sub-contractors

Hick Hargreaves & Co. Limited, Soho Iron Works, Bolton

H. 136

"TUBEND" welding fittings

B.K.L. ALLOYS are proud to record their association with the engineering development of Nuclear Power

The 'Tubend' label will be found on tens of thousands of Return Bends in the boilers, superheaters and economisers of Bradwell Power Station. The close nesting of tubes, which is essential in these units, was made possible solely by the extremely tight tolerances to which the Bends are formed.

'TUBEND' RANGE OF WELDING FITTINGS

90°, 45° Elbows
180° Return Bends
Equal and Reducing Tees
Caps
Concentric and Eccentric Reducers ½" to 12"

Carbon Steel
Stainless Steel
Alloy Steel
Aluminium
Monel Metal

Two new TUBEND leaflets have just been prepared. Send for your copies !

B·K·L ALLOYS LTD
ENGINEERING DEPARTMENT

BIRMINGHAM FACTORY CENTRE
KINGS NORTON, BIRMINGHAM, 30, ENGLAND
Tel. KIN 4231/9 'Grams "TESTAL" BIRMINGHAM

View of Plate Shop, Bridge Works, Wickford.

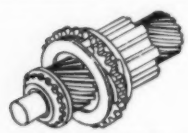
Contractors to the Admiralty and Central Electricity Authority for over 25 years. Now fabricating mild steel cylinders for Bradwell Nuclear Power Station 7' 6" internal diameter × $\frac{3}{4}$" thick tolerance on diameter plus or minus $\frac{1}{8}$". Cut oblique each end off centres. Weight approx. 6 tons each.

EDWARD FARR LIMITED

METAL PLATE WORKERS & ENGINEERS

BRIDGE WORKS, WICKFORD, ESSEX. *Telephone:* Wickford 2380

Reg. Office. NAPIER WORKS, LONDON, E.6. *Telephone:* Grangewood 3431/3



Synchro Self Shifting

S.S.S.

CLUTCHES

S.S.S. Self-engaging and Disengaging Clutches are incorporated in all pony motor drives for gas circulators, and also for preventing the backward turning of the gas circulators themselves. Shockle s in engagement and disengagement, S.S.S. clutches are designed and constructed for machinery necessitating the highest reliability, as for Bradwell Nuclear Power Station.

FLUIDRIVE ENGINEERING CO. LTD.

Fluidrive Works · Isleworth · Middx.

Fabricated by

YARROW

. . . the bodies for twelve 60" Tansphere Valves being supplied by Hopkinsons Ltd for Bradwell-on-Sea Nuclear Power Station

YARROW & CO. LTD

SCOTSTOUN, GLASGOW, W4

SCOTLAND

Reproduced by courtesy of C. A. Parsons & Co. Ltd.

A typical example of an all-welded Outer Stator Casing, weighing 57 tons, manufactured in our works for a 120 MW Turbo-Generator.

For all types of Heavy Platework and Steel Fabrications . . .

T.B. PEARSON & SONS LTD.

Wincomblee Road, Walker, Newcastle upon Tyne, 6 · Telephone: Wallsend 64081-2-3

FABRICATED STEEL LADDERS, HOLDING DOWN BOLTS AND HOOK BOLTS, ETC.
Supplied to
SIR ROBERT MACALPINE & SONS for BRADWELL POWER STATION

W. & C. TIPPLE LTD.

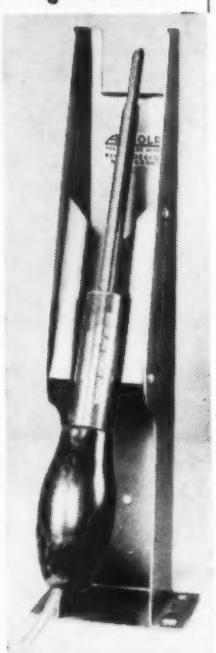
STEEL AND IRON STOCKHOLDERS

TOOLS AND ENGINEERS EQUIPMENT ·:· POWER TRANSMISSION APPARATUS

Canning Town, London, E.16
ALBERT DOCK 3111 (8 lines)

ADCOLA
(Regd. Trade Mark)

ELECTRICAL SOLDERING EQUIPMENT



Illustrated
PROTECTIVE SHIELD *List No. 68*
$\frac{3}{16}$" DETACHABLE BIT MODEL
List No. 64
(Factory bench line assembly etc.)

Also Manufacturers of
Solder Pots, P.V.C. and Polythene Cable Strippers in all volt ranges

Catalogues, etc. write or 'phone proprietors and manufacturers, Head Office, Sales and Service.

ADCOLA PRODUCTS LTD
GAUDEN ROAD
CLAPHAM HIGH STREET
LONDON, S.W.4
Telephones: MACaulay 3101 & 4272

PETERS & BARHAM
LTD

SOUTH STREET · ROMFORD · ESSEX
TEL. ROMFORD 44141/7 · TELEX 23343

CONCRETE
AGGREGATES

TO
BRITISH STANDARD
SPECIFICATION

Supplies Made to Contracts in Essex and Greater London

A SUBSIDIARY OF
CAWOOD WHARTON
& CO. LTD

SHELTON IRON & STEEL LTD
CONSTRUCTIONAL DEPT. STOKE-ON-TRENT STAFFS

STEELWORK FOR BUILDINGS & INDUSTRIAL APPLICATIONS (RIVETED OR WELDED)

APPROVED CONTRACTORS TO THE U.K. ATOMIC ENERGY AUTHORITY

CLAY CROSS

(IRON & FOUNDRIES) LIMITED

MANUFACTURERS OF

2" TO 66" DIAMETER CAST IRON PIPEWORK

FOR

THE COOLING WATER MAINS &
CULVERTS BEING INSTALLED

AT

BRADWELL

NUCLEAR POWER STATION

CLAY CROSS

PHONE :—
CLAY CROSS 2151

DERBYSHIRE

GRAMS :—
JACKSON, CLAY CROSS

COPES

BOILER FEED WATER REGULATORS

(of special design)

were chosen for use in the
Bradwell and Berkeley
Nuclear Power Stations

COPES REGULATORS LIMITED
9 SOUTHAMPTON PLACE, LONDON, W.C.1.
Tel: CHANCERY 7075

CAST IRON PIPES

SAND SPUN
METAL SPUN
VERTICALLY CAST
& FITTINGS

with run-lead or flexible joints

THE STAVELEY IRON & CHEMICAL CO. LTD.
NR. CHESTERFIELD

OUR PART IN THE BRADWELL STORY...

At Booths Hall, Knutsford, Cheshire, the design offices of the Nuclear Power Plant Company Limited, the electrical installations have been supplied by:—

G. ACTON, *Electrical Contractors*
73, KING ST, KNUTSFORD, CHESHIRE
Telephone: **Knutsford 178**

Industrial First Aid Supplies Ltd.

offer their services—anything from a safety pin to equipping a First Aid or Ambulance Room

Instruments—Scissors, Forceps, Scalpels etc.
Enamelware—Bowls, Kidney Dishes, etc.
Aseptic Furniture—Stretchers, etc.

All types of First Aid Dressings, Cotton Wool, Lints, Bandages, also Elastic Adhesive and the new type **Waterproof Plasters** as laid down for efficient service—Relative to production.

Various First Aid Cabinets, Boxes and Satchels—Standard range or made to specification.

It has been our pleasure to supply equipment to NPPC—Bradwell.

Please address enquiries to:
6 BROWN STREET, MANCHESTER, 2 · *Telephone:* BLAckfriars 9544

Tudor

are pleased to announce that they have

been awarded contracts for supplying

batteries and associated equipment for

BRADWELL NUCLEAR POWER STATION

Standby battery for Reactor Building essential supplies (sub-contract from A. Reyrolle & Co. Ltd), Station batteries with charging rectifiers and D.C. switchboards for switchgear operation and emergency supplies (sub-contract from The Nuclear Power Plant Co. Ltd).
Tudor have also supplied batteries and associated equipment to the following nuclear power stations:

CALDER HALL 'A'
CALDER HALL 'B'
CHAPEL CROSS
DOUNREAY

(Supplied under sub-contracts from:
A. Reyrolle & Co. Ltd.
The English Electric Co. Ltd.
Brush Electrical Engineering Co. Ltd.)

Tudor

Specialists in battery work for nuclear power stations

THE TUDOR ACCUMULATOR COMPANY LTD., 137 VICTORIA STREET, LONDON SW1 TEL: TATe Gallery 0307

WORKS: DUKINFIELD, CHESHIRE TEL: ASHTON-UNDER-LYNE 1651

T.168

THREE DATES

654

1715 approx.

1957

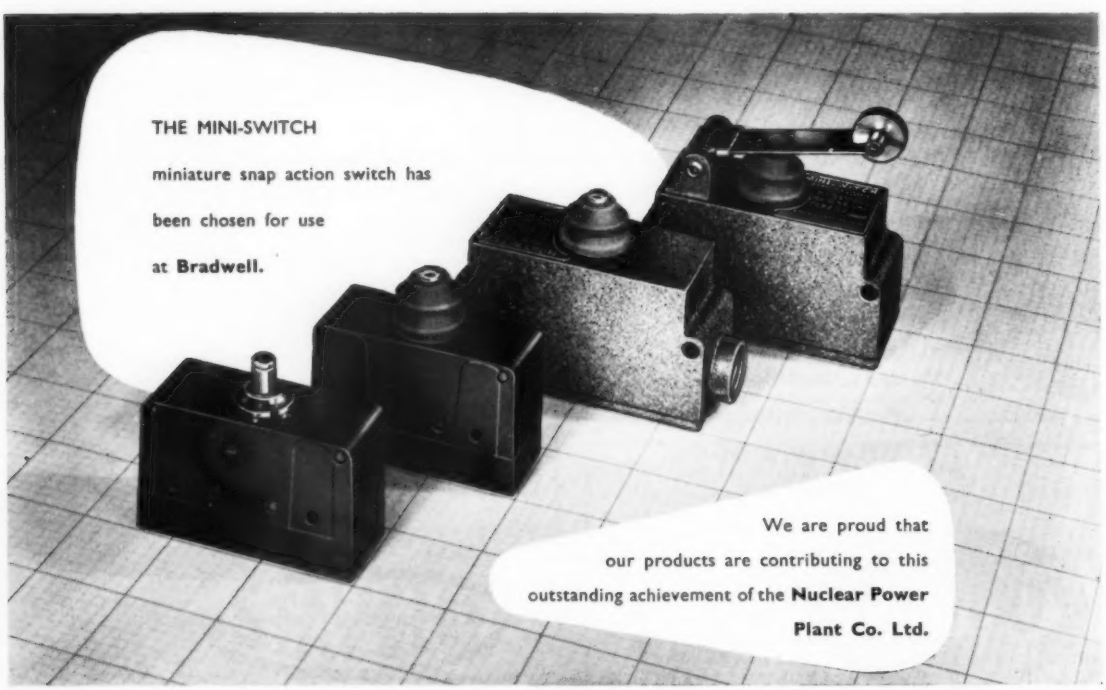
Discharging Baltic Softwood at the Wharves, Maldon.

TIMBER · JOINERY · BUILDERS' MATERIALS

JOHN SADD & SONS LTD.

MALDON, *Phone:* **131** **CHAncery 7214 LONDON**

On the Blackwater Estuary—at Bradwell-juxtu-Mare, one of our first Christian Churches was established, St. Cedd—more widely known as St. Peter's-on-the-Wall.
At Maldon, Sadd's established a contemporary Timber and Sawmilling business subsequently using the waterway for importing Baltic Softwoods from which has developed Maldon's main industry — Timber and Joinery manufacturing.
Bradwell-on-Sea selected for one of Britain's Nuclear Power Plants. The Blackwater Estuary has for the third time been the nucleus of far reaching changes of national importance.


THE MINI-SWITCH
miniature snap action switch has
been chosen for use
at **Bradwell.**
We are proud that
our products are contributing to this
outstanding achievement of the **Nuclear Power**
Plant Co. Ltd.

CR AIG & DERRICOTTCO LTD

Royal Works, Sutton Coldfield, England

Telephone: Sutton Coldfield 2547

550

for BRADWELL

550 Brookhirst motor starters are on order for Bradwell, the nuclear power station being built by the Nuclear Power Plant Co. Ltd., for the Central Electricity Authority. They will control vitally important plant—turbine auxiliaries and reactor essential auxiliaries; fuel element handling plant; control rods and safety rods.

Being awarded this large contract for Bradwell is a fine tribute to the confidence placed in Brookhirst quality and dependability. Following acceptance for many other major nuclear engineering projects, it is proof of Brookhirst leadership in motor control in yet another industry.

Brookhirst motor control gear is also on order in very large quantities for the United Kingdom Atomic Energy Authority's establishments at DOUNREAY and CHAPEL CROSS, and is already in successful operation at CALDER HALL, CAPENHURST, WINDSCALE, and SPRINGFIELDS.

BROOKHIRST

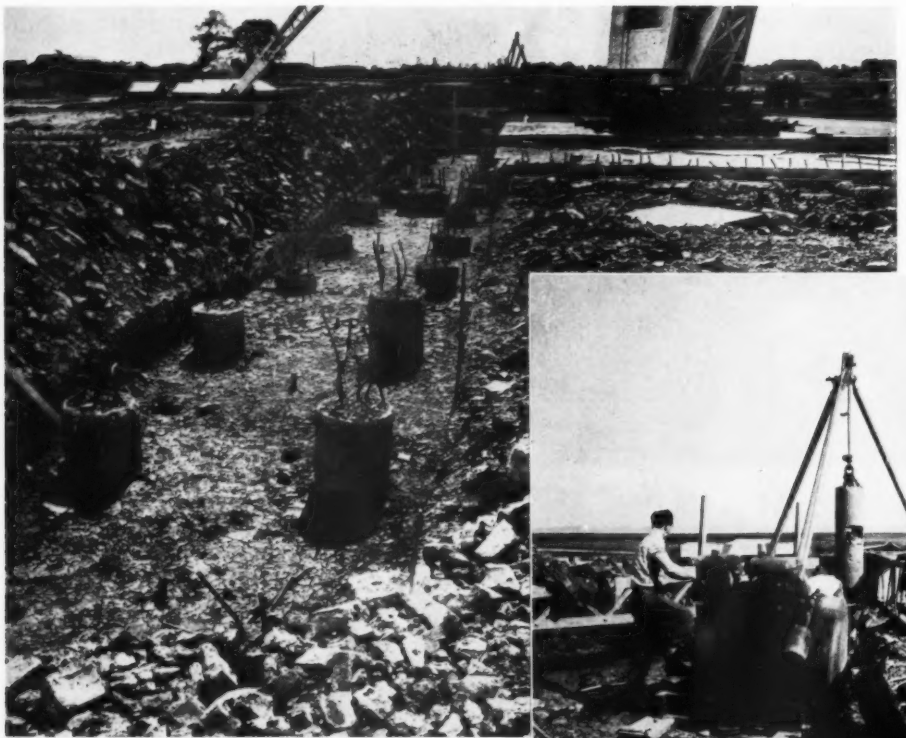
BROOKHIRST SWITCHGEAR LIMITED · CHESTER

A METAL INDUSTRIES GROUP COMPANY

cvs. 56.

THE BRADWELL STORY

BRADWELL NUCLEAR POWER STATION



The Nuclear Power Station is being constructed by the Nuclear Power Plant Company Limited, the principal member of which is Sir Robert McAlpine & Sons.

The Cementation Company constructed approximately 350 17″ diameter bored piles—some of which were raked to give stability—to provide the foundation for a Goliath Crane which will be used for the erection of the Reactor Blocks.

BORED PILING BY

The CEMENTATION COMPANY LIMITED

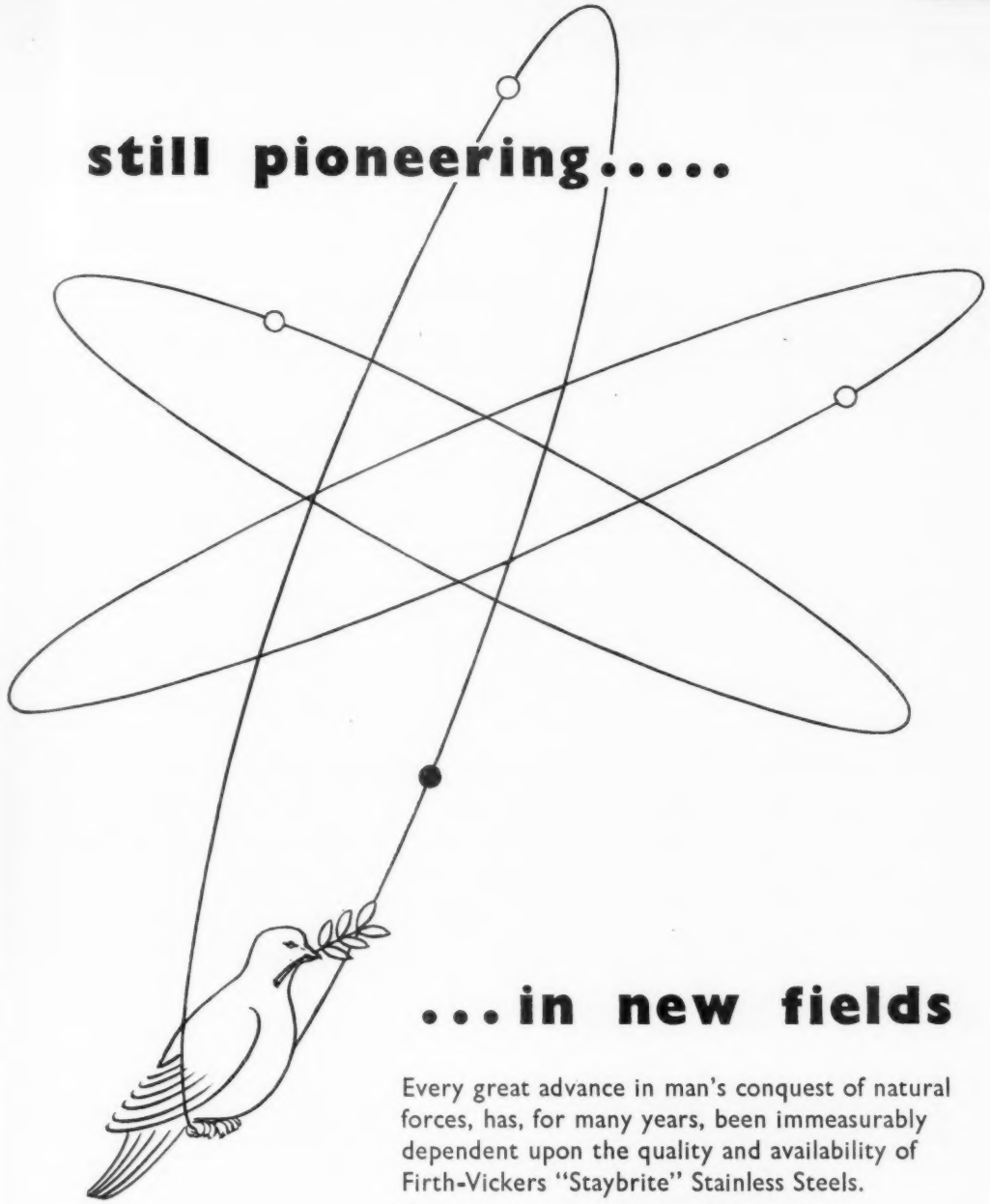
HEAD OFFICE

20 ALBERT EMBANKMENT · LONDON · S.E.11

Telephone: RELIANCE 7654 (15 lines)

BENTLEY WORKS · DONCASTER

still pioneering.....



...in new fields

Every great advance in man's conquest of natural forces, has, for many years, been immeasurably dependent upon the quality and availability of Firth-Vickers "Staybrite" Stainless Steels.

The special engineering problems of this Nuclear Age depend upon the steels which Firth-Vickers have developed and are still developing in the corrosion, heat and creep-resisting fields.

FIRTH - VICKERS STAINLESS STEELS LTD., SHEFFIELD

TELEPHONE: SHEFFIELD 42051

BRADWELL NUCLEAR POWER STATION

SKINNINGROVE IRON COMPANY LTD.

have supplied
ROLLED STEEL SECTIONS
to Member Firms of the
Nuclear Power Plant Company Ltd.

SKINNINGROVE IRON CO., LTD. P.O. BOX No. 1, SALTBURN, YORKS, Tel. LOFTUS 212

AND NOW AT BRADWELL!

WHEN SPECIAL PURPOSE TRANSPORT TANKS ARE REQUIRED

★ *DARHAM* *CAN PROVIDE THEM EFFICIENTLY & QUICKLY*

Engineers and makers of

TRANSPORT TANKS
STORAGE TANKS
PRESSURE VESSELS

Fabrications in

MILD STEEL
STAINLESS STEEL
and ALUMINIUM

Constructional Plant Refuelling Unit by Darham, for operation on site at Bradwell.

WORKS
BASILDON, ESSEX
AND
DURHAM CITY.

★ **DARHAM INDUSTRIES (LONDON) LIMITED**
13 VICTORIA STREET · LONDON · S.W.1
Phone: ABBEY 2231-3

"Ritecure"

for

CONCRETE CURING

Approved and supplied to
Bradwell and Berkeley
Nuclear Power Stations

STUART B. DICKENS LIMITED
Manor Way, Boreham Wood, Herts.
Telephone: Elstree 2211

SPUN CONCRETE LTD Suppliers to BRADWELL Nuclear Power Station

RYE HARBOUR
SUSSEX
Tel. : Rye 2362

LICHFIELD ROAD
BRANSTON
STAFFS
Tel. : Barton-u-Needwood 286

CENTRIFUGALLY SPUN PIPES and TUBES
Also manufacturers of
MANHOLES, PIPE SPECIALS, LIGHTING COLUMNS, TUBULAR PILES and ALL FORMS OF PRECAST CONCRETE
Our Design Staff is at your service

BINDING Nuclear Power
The journal of British nuclear engineering

You often want to refer to NUCLEAR POWER . . .
. . . these Easibinders will hold up to 6 copies of NUCLEAR POWER for quick and easy reference

12/6 each plus 1/6 postage and packing

TO ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W1

Please supply _____ Easibinders for NUCLEAR POWER

NAME _____

ADDRESS _____

_____

PRICE 12/6 BINDER, I ENCLOSE _____

SPERRY

develop and design Control Systems

Manufacturers of:—

SYNCHROS

for Reactor Control Systems, 1¾ in. diameter case models
and slab units specially designed for
high-temperature operation

CONTROL ROD POSITION INDICATORS

D.C. STEPPING MOTORS

and

COMPLETE SERVO SYSTEM ENGINEERING

SPERRY GYROSCOPE COMPANY LIMITED · GREAT WEST ROAD · BRENTFORD · MIDDLESEX
TELEPHONE: EALING 6771

Where Mobility is essential

HEAVY DUTY X-RAY *equipment*

Chosen by Messrs. Whessoe Limited, and Head Wrightson & Co., Ltd., these X-Ray units will be used to check the thick section welded plates now called for on Nuclear Power Stations. These equipments utilise a constant potential circuit with metal rectifiers giving long trouble free performance. Full details are available on request.

300 OR 400 KV

PANTAK LIMITED

72-76 ALPHA STREET, SLOUGH, BUCKS. **Telephone: SLOUGH 21129**

NUCLEAR GENERATING STATIONS

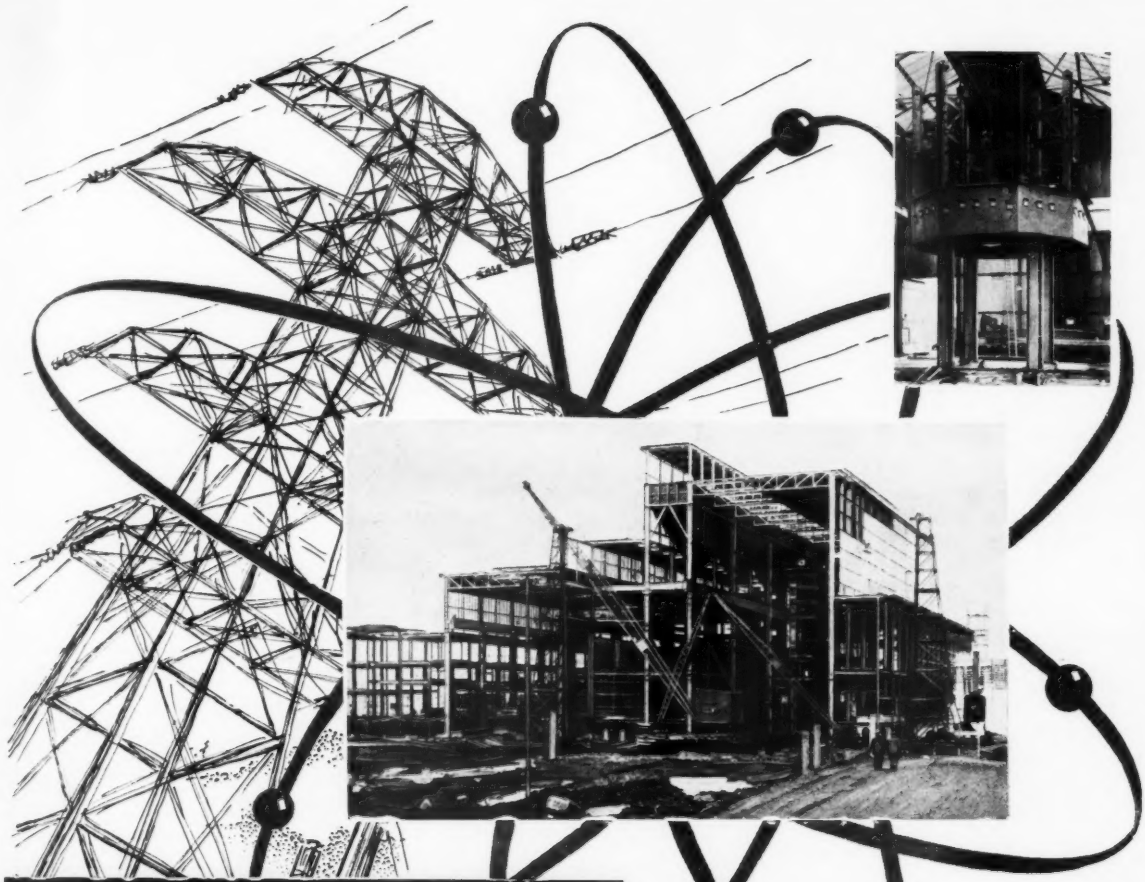
For **D.C. SWITCHGEAR** *specify*

The above shows a D/C CUBICLE TYPE SWITCHBOARD equipped with withdrawable D/C breakers, supplied to Harbour Boards, Steelworks and Atomic Power Stations.

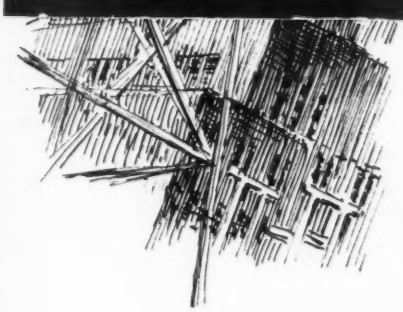
WHIPP & BOURNE LTD.

SWITCHGEAR SPECIALISTS

CASTLETON · ROCHDALE · LANCS



Steel for the Atomic Age



Power for industry and commerce epitomises Wright Anderson. In the provision of steel buildings for every industry they have the resources and experience to ensure the most efficient contracting from planning to completion.
If you are thinking ahead now is the time to call in Wright Anderson whose assistance can be a powerful factor in matters of time and economy.

WRIGHT ANDERSON & CO. LTD.

CONSTRUCTIONAL ENGINEERS AND BRIDGE BUILDERS

G.P.O. BOX 2, GATESHEAD 8, CO. DURHAM

Tel. Gateshead 72246 (3 lines). Grams: "CONSTRUCT Gateshead"
London Office: Regent House, Kingsway, W.C.2. Tel. HOLborn 9811

CONTRACTORS TO H.M. GOVERNMENT, CENTRAL ELECTRICITY AUTHORITY, NATIONAL COAL BOARD, ATOMIC ENERGY AUTHORITY AND CROWN AGENTS FOR OVERSEAS GOVERNMENTS AND ADMINISTRATIONS

HIGEARS

For MACHINE, AGITATOR, CONVEYOR AND WINCH DRIVES, etc.

TOTALLY ENCLOSED **GEAR UNITS**

HELICAL GEAR UNITS SINGLE & DOUBLE REDN.

HORIZONTAL HELICAL GEARED MOTOR UNITS

'FANCOOL' WORM GEAR UNITS

VERTICAL HELICAL GEARED MOTOR UNITS

DOUBLE REDN. WORM GEAR UNITS

GEARS

WE SUPPLY ALL TYPES OF GEARS IN SELECTED MATERIALS

SPUR, SPIRAL AND DOUBLE HELICAL UP TO 56″ DIA.

BEVEL GEARING UP TO 36″ DIA.

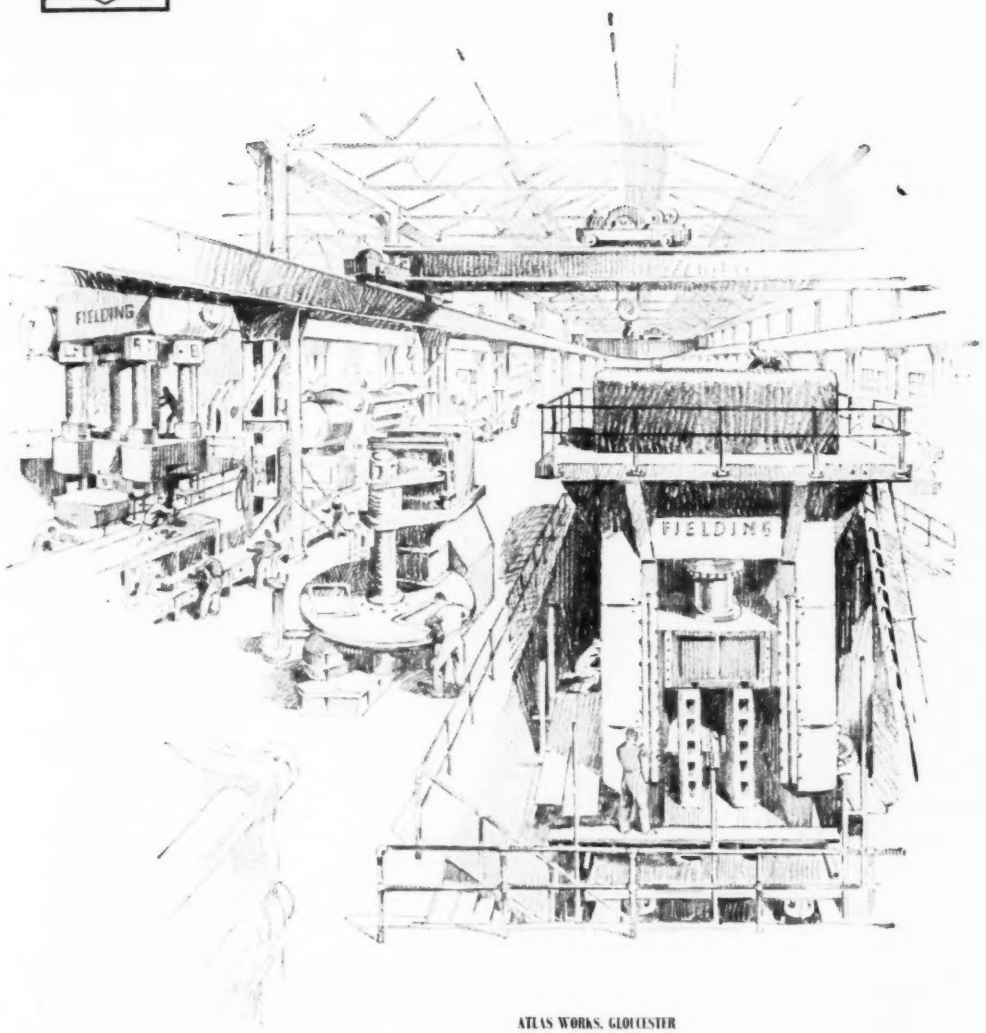
WORM GEARS UP TO 18″ CRS.

We solicit enquiries for all types of Gear Units or Machine Cut Gearing. Leaflets describing our products will be sent on application

HIGHFIELD GEAR & ENGINEERING CO. LTD.

KARRIER WORKS, HUDDERSFIELD, ENGLAND

Phone : **Huddersfield 4490/1/2** Grams : **Higears, Huddersfield**



ATLAS WORKS, GLOUCESTER

Founded in 1866 the production facilities at Atlas Works have been progressively expanded and developed and today provide an efficient equipment staffed by skilled personnel for the quality production of the Company's products.

FIELDING & PLATT LTD
ATLAS WORKS
GLOUCESTER • ENGLAND

SERVICE FOR NUCLEAR ENGINEERING

METAL WORK

PROTOTYPES

PRODUCTION

After many years of service in metal-work design and production for various industries, we now offer our services to those engaged in Nuclear Power projects.
We are already well known to many advertisers in this publication and we are also at present engaged on important contracts for the UKAEA.

May we help in your Nuclear Power problems?

E. G. BROWN & CO. LTD.
(SHEET METAL ENGINEERS)
WEST RD., TOTTENHAM, N.17
Telephone: TOTtenham 2257/8/9

E. G. Brown & Co. Ltd

Design, fabrication and complete installation in Corrosion Resistant UNPLASTICISED P.V.C.

EXTRUDEX Limited, Creative Engineers in Plastics, offer a complete service in the design, fabrication and installation of ventilation and fume extraction plant, from plant to fan, fan to fume scrubber, and beyond, in Unplasticised P.V.C. Complete resistance to powerful corrosive chemicals is a unique feature of this remarkable material.

EXTRUDEX Limited are suppliers to Harwell and other atomic energy establishments.

HI-PACT Another EXTRUDEX first-in-the-field! Possesses 15 times the impact resistance of the toughest corrosion resistant plastic. Available in bulk, and in extrusions up to 8"

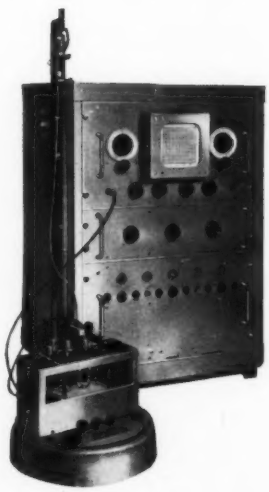
EXTRUDEX *Creative Engineers in Plastics*

Your enquiries are welcome, and the Extrudex advice service is freely available at all times.

EXTRUDEX LTD · **WESTERN ROAD** · **BRACKNELL** · **BERKS** · ***Telephone: Bracknell 1000***

WHICH END OF THE PROBLEM IS YOURS?

THE PRODUCTION OF RESULTS FROM ANALYSIS?

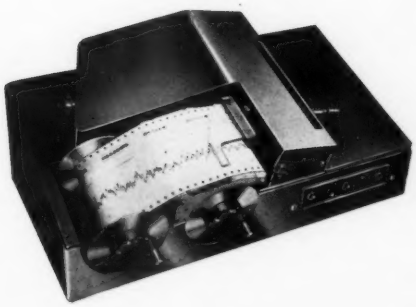


With the SINDAK Cathode Ray Polarograph, an accurate presentation of the chemical analysis of your product is displayed at a speed and sensitivity hitherto unobtainable by conventional means.

Available in the near future—an Anodic Conversion Unit for even greater versatility.

OR

THE ANALYSIS OF RESULTS FROM PRODUCTION?



SINDAK Data Reduction equipment speeds up the numerical analysis of recorded data.

K1015 Trace Reader.
A simple and effective device for reading Analogue Trace records and printing out in digital form, on a fixed scale of 999.

K1020 Trace Reading equipment.
A more ambitious system with Calibration facilities and Visual Display.

sindak

EQUIPMENT FOR CALCULATION AND ANALYSIS

SOUTHERN INSTRUMENTS
COMPUTER DIVISION
CAMBERLEY · SURREY
TELEPHONE: CAMBERLEY 2230 (3 LINES)

FOR

CONTROL VALVES

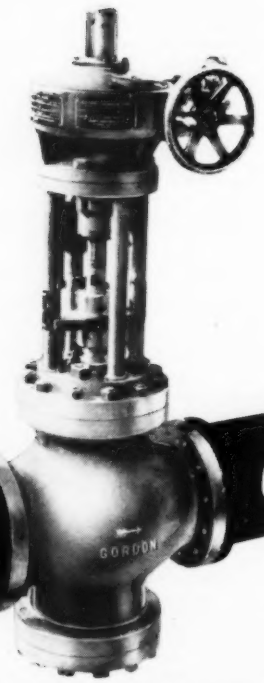
OF ALL SIZES

IT WILL PAY YOU

TO GET IN TOUCH WITH

GORDON

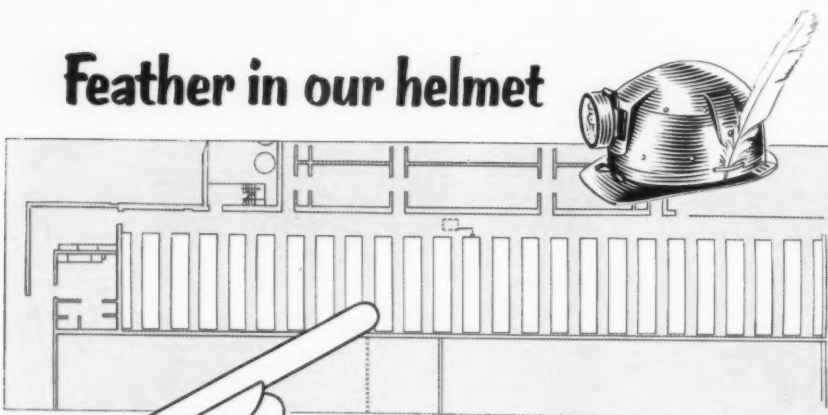
Steam · Water · Gas etc.



JAMES GORDON & CO. LTD., DALSTON GARDENS, STANMORE, MIDDLESEX (WORDSWORTH 3631)

A SUBSIDIARY OF ASSOCIATED AUTOMATION LTD.

Feather in our helmet



Reproduced by permission of N.C.B.

The ablution scheme at Calverton Colliery Notts is an example of modern industrial welfare by the National Coal Board.
The locker accommodation was supplied and erected by Rubery Owen of Wrexham.
The installation comprised 176 double sided 3′ 0″ wide nests, 36 single sided nests. All lockers double-tier, 8′ 10″ high, plenum heated. Total number of lockers . . . 2,328.
Rubery Owen specialise in locker accommodaton for such ablution schemes in mining, foundry, nuclear and heavy engineering industries. A range of standard lockers for protection of personal belongings in offices, factories, schools and many other institutions, is also available.

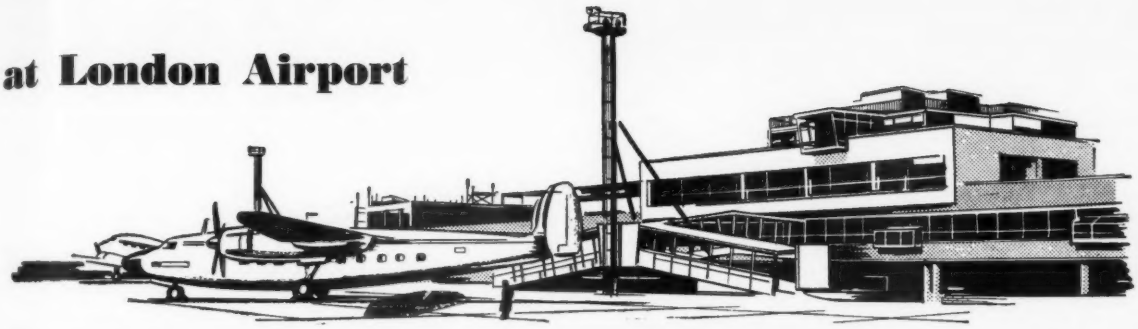
CALVERTON COLLIERY LOCKER INSTALLATION

by RUBERY OWEN

RUBERY, OWEN & CO., LTD., INDUSTRIAL STORAGE EQUIPMENT DIVISION, WHITEGATE FACTORY, WREXHAM, N. WALES.
Telephone: Wrexham 3566-8
TERRITORY OFFICES: LONDON - MANCHESTER BRISTOL GLASGOW

A122

at London Airport



CORRUSTEEL

ARMOURED CABLE

wandleside of wandsworth

Illustration shows "CORRUSTEEL" Armoured Cable in the Main Feeder Trunking at London Airport's new building. Electrical Contractors, The L.E.B. Contracting Section, Chelsea Manor Street, S.W.3

WANDLESIDE CABLE WORKS LTD. · 106 GARRATT LANE WANDSWORTH LONDON · S.W.18

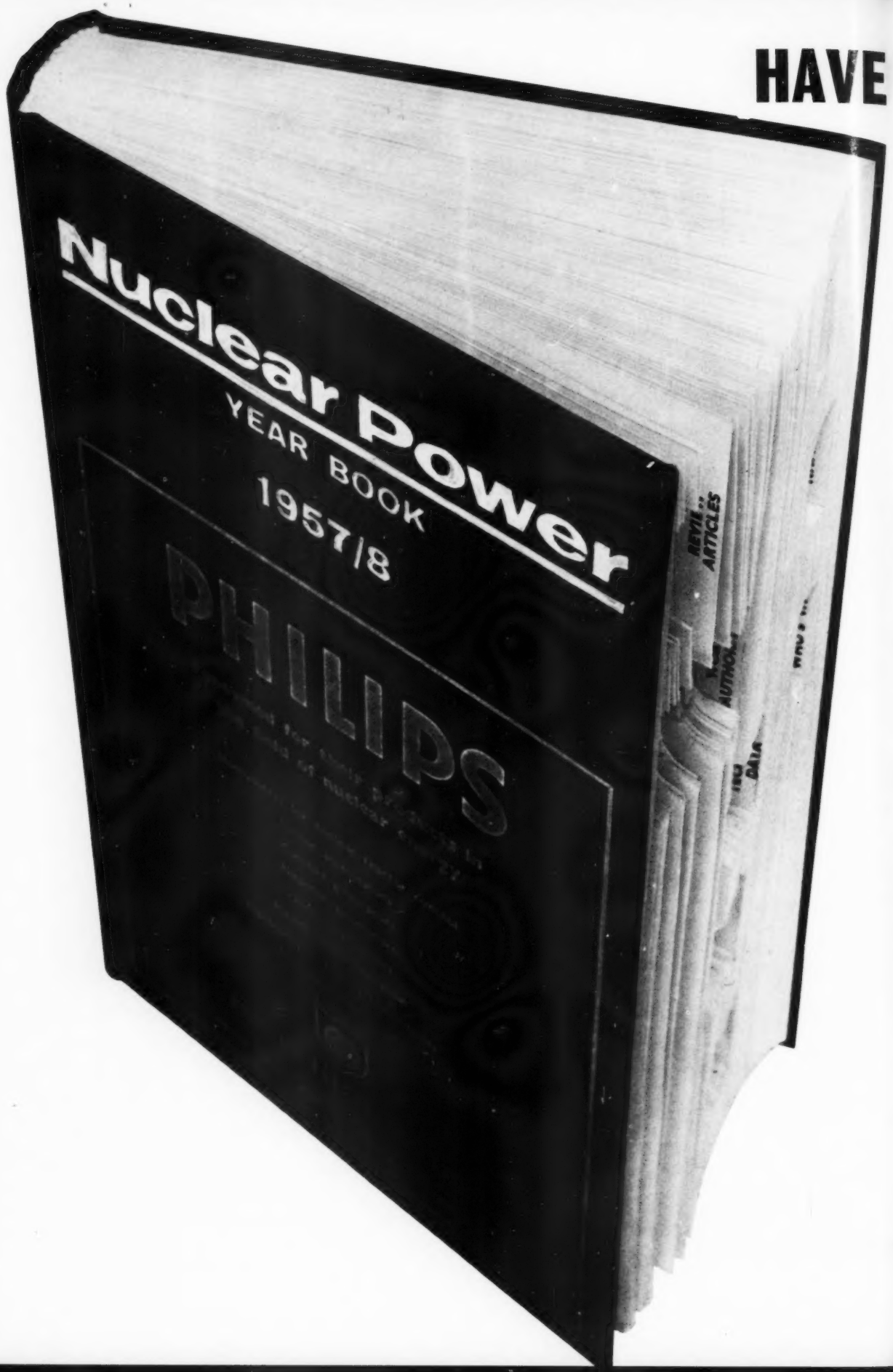
Telephone: BATtersea 2273-4

Telegrams: "Wandleside, London"

One of **FALKS** Group.

WANDLE · BRITISH MADE · CABLE

LONDON OFFICE: 21 Fitzroy St., London, W.1. BELFAST OFFICE: Dublin Rd., Belfast, N. Ireland. BRADFORD OFFICE: 19 Union St., Bradford, Yorks


HAVE
Nuclear Power
YEAR BOOK
1957/8
PHILIPS

YOU GOT YOUR COPY YET ?

This nuclear reference book has been acclaimed throughout the world as a MUST for all firms already in atomic energy, for all firms anxious to assess the great new potential markets opening up to them. In short, if atomic energy is or could be your business the Nuclear Power Year Book is indispensable to you.

contents include . . .

1 **FOREWORD** by Lord Mills, Minister of Power

2 **REVIEW ARTICLES** Current trends in applied atomic energy reviewed authoritatively by experts in twelve outstanding articles

3 **WORLD AUTHORITIES** History, organization and programme of 50 national and international atomic energy bodies

4 **TECHNICAL DATA** Nuclear constants, fission data and other useful information

5 **ISOTOPES** The most comprehensive table ever published, lists every known nuclide. Other articles cover whole field of isotope techniques

6 **COMPANY ADDRESSES** Details of practically every British firm working in nuclear energy

7 **BUYERS GUIDE** Classified listing by products of all that is manufactured by the British nuclear industry

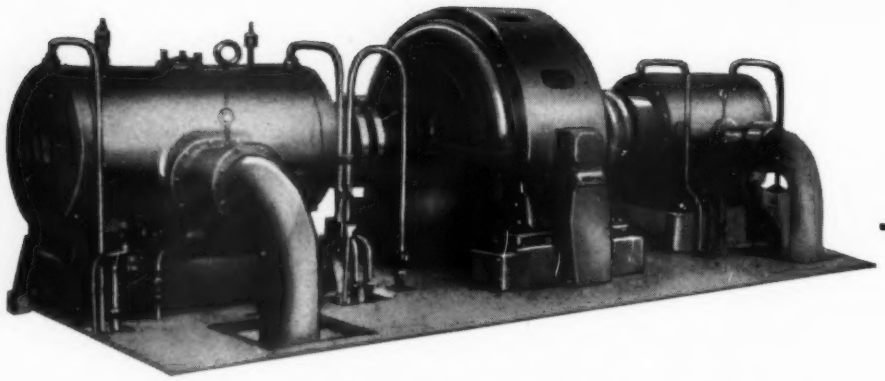
8 **TRADE NAMES** Products sold under registered titles

9 **WHO'S WHO** Biographical details of the leading men in British nuclear energy

OVER 500 PAGES

PRICE United Kingdom £2.2.0 plus 1/- for postage and packing
US and Canada $8 plus 50c " " " "
other countries £3.3.0 plus 1/6 " " " "

ROWSE MUIR PUBLICATIONS LTD., 3 PERCY STREET, LONDON, W.1, MUS 8252



HOLLAND - S. L. M.

ROTARY COMPRESSORS AND VACUUM PUMPS

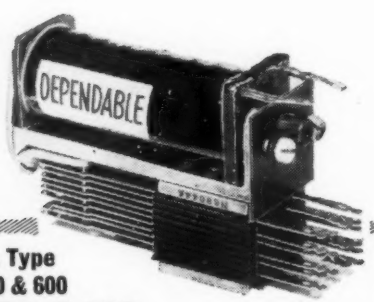
LOW MAINTENANCE COSTS · LONG LIFE
INITIAL EFFICIENCIES MAINTAINED OVER YEARS OF SERVICE

The B. A. Holland Engineering Co. Ltd.

15, DARTMOUTH STREET, LONDON, S.W.1.

Telephone: WHI 2823. Telegrams: Picturable, Phone, London.
Works: SLOUGH, BUCKS.

DEPENDABLE RELAY CO. for DEPENDABLE AUTOMATION

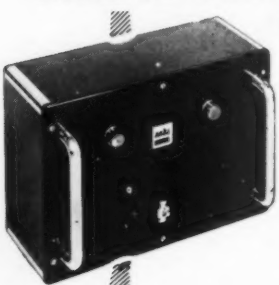


P.O. Type 3000 & 600

RELAYS

Manufactured to your specification to A.I.D. and I.E.M.E. standards.
COILS up to 80,000Ω. CONTACTS up to 8 amp.
INSULATION up to 5 kv. Prototypes 7-14 days.
PROMPT DELIVERY — PROMPT QUOTATIONS
SIEMENS high-speed types also supplied.
Specialists in tropicalisation. Transistorised relays.
Contractors to leading manufacturers, P.O. and Govt. Depts.

STANDARD SELF-CONTAINED CONTROL UNITS FOR

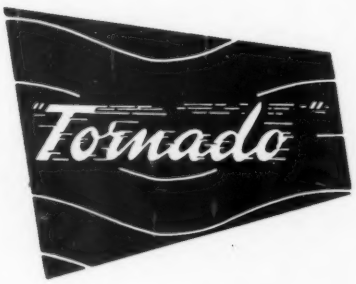


- PRODUCTION CONTROL
- COUNTING
- BATCH WORK
- PROGRESS
- TIMING
- SWITCHING
- POWER HANDLING
- LIQUID AND GRAIN LEVEL CONTROL
- TEMPERATURE AND FURNACE CONTROL

DEPENDABLE ELECTRONIC RECORDER

● Continuous Strip Chart ● 5in. graph ● 3 speeds
● Power driven pen. ● Immediate starting torque
● Full-scale drive 3 sec. ● " Plug in " oscillator chassis ● Black ebony finish Instrument Case.
● Research, industrial and medical applications.

12a, Tottenham Street, LONDON, W.1. *'Phone:* LANgham 7391/2 *(NEAR GOODGE ST. STATION)*



FANS and BLOWERS

FOR THIS ATOM AGE

KEEPING PACE with the demands of successive atomic projects, 'Tornado' fan engineering equipment is today assisting the exacting work in UKAEA establishments. In addition to equipment at Aldermaston, Capenhurst, Dounreay, Foulness, Harwell, Risley, Springfields and Windscale, other Keith Blackman fans and blowers are being used experimentally elsewhere. The demands of the atomic industry are often unusual but years of experience and unrivalled facilities have made Keith Blackman "specialists in the unusual."

If the problem involves the handling of air or other gases, contact

Keith Blackman

Fan makers since 1883

KEITH BLACKMAN LTD · MILL MEAD ROAD · LONDON · N17

or at Manchester · Newcastle · Birmingham · Leeds · Glasgow · Leicester · Bristol

'Tornado' equipment includes: CO_2 COOLANT BLOWERS and HEAT EXCHANGER COOLING FANS. FANS FOR VENTILATION, DUST REMOVAL and HIGH TEMPERATURE EXTRACTION · BLOWERS FOR GAS BOOSTING, DRY SCRUBBERS and VESSEL VENTILATION. Also AIR SAMPLING COMPRESSORS, AIR FLOW CONTROL UNITS, BACK PRESSURE VALVES, STEEL FABRICATIONS and the SHOT CLEANING of HEAT EXCHANGERS.

T.A. 11362/843

first 500,000 kW a

A great step forward.

HINKLEY POINT the 500,000-kilowatt atomic power station for the Central Electricity Authority will be constructed by the ENGLISH ELECTRIC, BABCOCK & WILCOX, TAYLOR WOODROW Group. This new atomic power station is by far the largest yet ordered by the Authority, and will be the largest in the world. It represents a momentous step forward in Britain's vital programme of atomic power development.

The advance to a 500,000 kilowatt atomic power station, which approaches in capacity the largest of Britain's modern power stations using conventional fuels, has been rapid. Involving far more than a simple increase in size, it is an impressive technical achievement made possible by the ability of this team of famous engineers to draw upon a vast fund of design and constructional experience, working in full collaboration with the Atomic Energy Authority.

With exceptional and world-wide experience in designing and building large power stations, ENGLISH ELECTRIC, BABCOCK & WILCOX and TAYLOR WOODROW arranged in 1954 to work together as a Group in the new field of atomic power; they have been responsible for evolving, in association with the Central Electricity Authority, the advanced design of the new station at Hinkley Point.

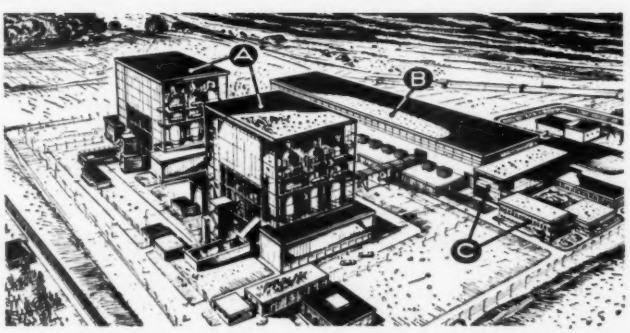
ENGLISH ELECTRIC

BABCOCK & WILCOX

TAYLOR WOODROW

atomic power station

An impression of the power station from a painting by Mr. Claude Buckle.



A Two reactors, each with 6 steam raising units

B Turbine hall with 6 main and 3 auxiliary steam turbo-alternator sets

C Workshops and administrative blocks

Worth Keeping Handy

Gardners

fully detailed catalogue giving electrical characteristics, dimensions, fixing centres, weights and prices of more than 600 transformers and chokes available for immediate delivery.

Revised edition obtainable on request from :—

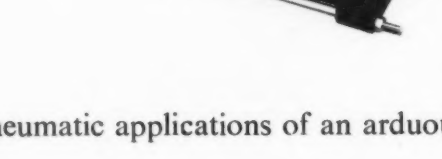
GARDNERS RADIO Ltd

SOMERFORD · CHRISTCHURCH · HANTS.

TEL. : CHRISTCHURCH 1025

Martonair

HEAVY-DUTY CYLINDERS



for all pneumatic applications of an arduous nature.

MARTONAIR LIMITED

Parkshot · Richmond · Surrey · England

AD 18

NUCLEAR POWER ORIGINATES IN THE DRAWING OFFICE

and Mason's manufacture the drawing office equipment

Thousands of Mason and Arclight drafting units have been installed in drawing offices throughout this country and in many parts of the world.

Many recent achievements in the development of nuclear power plant were planned with the aid of drawing office equipment manufactured by E. N. Mason & Sons Ltd.

There is a range of equipment available which consists of different types of drafting units, furniture and filing equipment, from which selection can be made to meet requirements in any style and size of drawing office.

The Mason organisation has been closely associated with the drawing office industry for more than 50 years and their service for producing planned drawing office layouts is available, without obligation, to all who are contemplating the equipping of new or existing offices.

The illustration above is published by courtesy of Messrs. G.E.C. Simon-Carves Atomic Energy Group, Erith, and is a view of their design office. A range of equipment, including the Mason Drafting Stand, was supplied for this section by E. N. Mason & Sons Ltd.

Full information is available from any of the following addresses:—

E. N. MASON & SONS LTD

ARCLIGHT WORKS, COLCHESTER **Telephone: Colchester 5191-8**

291-293 HIGH HOLBORN, LONDON, W.C.I. Tel. CHA 6411
13-15 ST. VINCENT PLACE, GLASGOW, C.I. Tel. Cen 3775
8-10 NEWTON STREET, MANCHESTER, 1. Tel. Cen 9221

51 VICTORIA STREET, SHEFFIELD, 1. Tel 21776
3 UNITY STREET, BRISTOL, 1 Tel. 26996
6 BRITANNIA HOUSE, WELLINGTON ST., LEEDS. 23537

From Drawing Board to Site

A. C. WILSON & PARTNERS LTD.

are pleased to announce that for the past two years they have been entrusted with the design and procurement of the following plants for remote handling, examination and processing of Nuclear Reactor fuels.

Pond Equipment — Chemical Plant, **DOUNREAY**

Facility for Experimental Loops for **DOUNREAY**
Materials Testing Reactor

Irradiated Fuel Element Laboratory,
WINDSCALE WORKS CUMBERLAND

Stripping Facility, Fast Reactor Chemical Separation Plant—
DOUNREAY

Fuel Element Heat Treatment—
SPRINGFIELDS

DESIGN HOUSE, THE MALL W.5

Telephones: Ealing 1942 and 9843

Shieldings

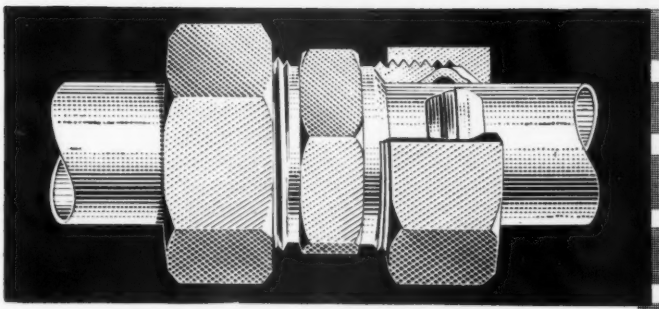
for the NUCLEAR ENGINEER

JENKINSONS are leading in serving the needs of the Nuclear Engineer in fulfilling the demand for the production of Protective Lead Shieldings in co-operation with many prominent firms engaged in this field. These firms have come to rely upon JENKINSONS for skilled and confidential co-operation where lead shieldings form an integral part of the equipment they produce. In addition JENKINSONS have installed at Dounreay, Polythene drains in all active ducts from Laboratory Blocks, Change Rooms, Glove Boxes, Sinks, Wash-hand Bowls and Showers; a branch of JENKINSONS productions in which they excel in an equal degree to their Lead work.

JENKINSONS are always pleased to co-operate with those firms seeking skilled design, production and installation of Protective Lead Shieldings for Nuclear and X-ray applications, Lead and Plastic Tank Linings, Plain or Lead covered Copper or Mild Steel Heating Coils, Stainless Steel Pipework, and Plastic Pipework.

Jenkinsons
CHEMICAL ENGINEERS
W. G. JENKINSON LIMITED
ARUNDEL STREET, SHEFFIELD 1 **Telephone: 27438-9**

FASTEST ON THE JOB!



compression joints

and the safest

Simplifix Joints save time and trouble. Beyond removing the burrs no work is required on the pipe ends. As the securing nut is tightened, the sealing ferrule is compressed on to the pipe without weakening it in any way.
Note: Simplifix fittings can be used on very thin walled tubing.
A full range of fittings, elbows, tees, crosses, etc., is available and illustrated in our catalogue which will be sent on request.

SIMPLIFIX COUPLINGS LIMITED
HARGRAVE ROAD
MAIDENHEAD
BERKS
Tel:Maidenhead 2271/4

SIMPLIFIX

This Way FOR MACHINING

Our machine tools are probably more varied and more up-to-date than you would find under any other roof in Britain. They are certainly capable of solving your production problems. In the Precision machine shop which is temperature controlled, dust-excluded and quite free from engineering noise, is a collection of precision tools which is unique. Our highly skilled operators turn out intricate shapes from the most intractable metals and have long experience of working stainless steel. Problems in nuclear engineering are in no way strange to us. We have developed new techniques at highly competitive cost and we are already putting them to good use.

In a nutshell; you will find the know-how, the machine tools and the capacity to deal with your nuclear engineering problems. For further information write to:—

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD BAGINTON, NEAR COVENTRY
Tel. Toll Bar 2261

THIS FREE 28-PAGE BOOKLET WILL SOLVE YOUR LEVEL PROBLEM

FOR ALL
LIQUIDS AND
SOLIDS
Such as
WATER
COAL & COKE
FRUIT JUICES
FLOUR
CEMENT
CHEMICAL SOLUTIONS
SAND
PARAFFIN
FLUE-DUST

Fielden AUTOMATION

FIELDEN ELECTRONICS LIMITED
WYTHENSHAW · MANCHESTER
Tel: Wythenshaw 3251, also Australia, Italy and U.S.A. Branch Offices: London, Birmingham, Stockton-on-Tees, Cardiff and Edinburgh.

on site

mobile teams and equipment providing

metal polishing

welding — metal spraying

shot blasting services

Enquiries invited for Atomic Energy Development Sites

send for brochure to:

STAINLESS EQUIPMENT CO.
(METAL FINISHERS) LTD

72, De Beauvoir Crescent,
LONDON, N.1.

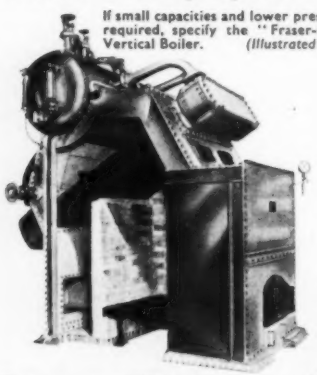
(M.O.S. approved) *Telephone: Clissold 4141, Bishopsgate 0707*

Specify

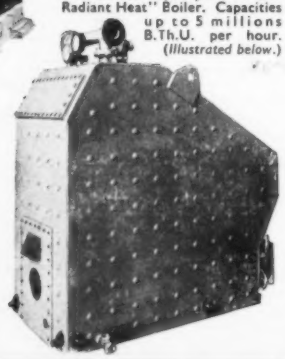
FRASER BOILERS

Whatever the purpose

If small capacities and lower pressures are required, specify the "Fraser-Culmen" Vertical Boiler. *(Illustrated on right.)*



For low pressure Steam or Hot Water Boilers specify the "Fraser Radiant Heat" Boiler. Capacities up to 5 millions B.Th.U. per hour. *(Illustrated below.)*



If pressures up to 500 lb. p.s.i. and capacities up to 10,000 lb. of steam per hour are required, specify the "Fraser" Water Tube Boiler. *(Illustrated above.)*

Illustrated details sent on request

Makers also of Class 2 Welded Pressure Vessels

FRASER & FRASER LTD.
BROMLEY-BY-BOW LONDON, E.3

Phone: ADVance 3266-9
Grams: Pressure Easphone London

sieving with

Endecotts
STANDARD TEST SIEVES

. . . NO CREVICES . . .

. . . PRECISION-WEAVE WIRECLOTH . . .

. . . NO BLIND SPOTS .

★ *Ask for data Sheet NP/57*

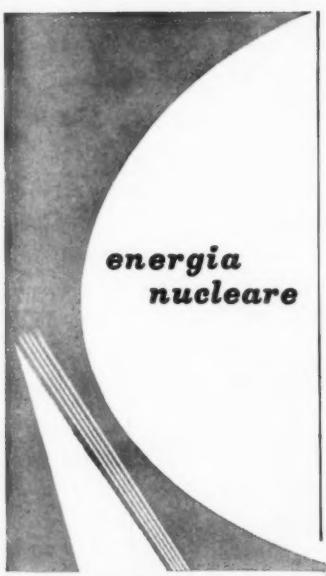
ENSURE ACCURATE AND SPEEDY SEPARATION
Standard Test Sieves to B.S.410:43 and U.S. Bureau of Standard (A.S.T.M.E11) down to No. 400 (37 microns).

"Endrock" Test Sieve Shakers

ENDECOTTS (FILTERS) LTD.
251 Kingston Road, London, S.W.19 LIBerty 8121/2

WE CARRY OUT
NON-DESTRUCTIVE TESTING
ANYWHERE IN THE WORLD
WITH
· X-RAYS · GAMMA RAYS · ULTRASONICS ·
· EDDY CURRENTS OR PENETRANTS ·

SOLUS-SCHALL LIMITED
15-18 Clipstone Street, Gt. Portland St. London W.1
Telephone: MUSeum 6342



The bi-monthly review of CISE (the Information Centre for Studies and Experience)

This journal covers all important developments in the field of nuclear technology in Italy

ORIGINAL RESEARCH PAPERS are published in English.

To keep abreast of trends in Italy you should read **Energia Nucleare**

Subscription rate per annum 45s

Subscription to sole agents
ROWSE MUIR PUBLICATIONS LTD
3 Percy Street, London, W1

energia nucleare

STEEL FABRICATING
AND
MACHINING SPECIALISTS

LLOYD'S CLASS II FUSION WELDED VESSELS
CONTRACT GUILLOTINING—96" × ¾"
HYDRAULIC FORMING & BENDING—150 TONS
PLATE ROLLING—120" × ¾"
PROFILE CUTTING UP TO 6" THICK
ARC & GAS WELDING

●

MACHINING CAPACITY
UP TO 86" DIAMETER & 144" LENGTH

●

OIL, WATER & ACID STORAGE TANKS
Ex-Works & Fabricated on Site

●

EXPERIMENTAL & RESEARCH CHAMBERS
VACUUM VESSELS, PROCESSING & STORAGE
TANKS, DUCTING, PIPEWORK
CHIMNEYS, HANDLING EQUIPMENT
HEAT EXCHANGERS & STRUCTURES

●

Enquiries invited

C.F.IDE ENGINEERING LTD.
EMPIRE WKS., RICHMOND ROAD
KINGSTON-ON-THAMES
Phone Kingston 6820 & 6272

SOLENOID VALVES

Designed to Customers Requirements

orifice 0.04 in. upwards
★
any pressure
★
normally open, normally closed, or three-way
★
direct acting or relay acting
★
any liquid or gas
★
up to 300° C.
★
standard, flameproof or intrinsically safe

Write for catalogue

ELECTRO-HYDRAULICS LTD
WARRINGTON Phone: Warrington 35241

It's certainly worth looking at!

Trust a cat to know a good thing when he sees it! And you can trust a welder to appreciate the value of "SIF-TIPS"—Britain's leading welding quarterly. It gives you all the latest news on Sifbronze welding rods and processes and answers the kind of problem you're meeting every day.

WHY NOT WRITE FOR A COPY NOW?

The Editor, "SIF-TIPS,"
Suffolk Iron Foundry (1920), Ltd.,
Stowmarket, Suffolk.

Please send regularly..... copy/copies of "SIF-TIPS."

NAME .....

ADDRESS .....

.....

NPR2

HIGH-PRECISION MACHINE-TOOLS

TOOLROOM-RESEARCH PRODUCTION

We specialise in Continental High-Precision Machine-Tools and Measuring Equipment. Built by Swiss Craftsmen to the highest standards, our wide range covers:—

★ ***Lathes***
★ ***Milling Machines***
★ ***Drilling Machines***
★ ***Grinders***
★ ***Jig-Borers, etc.***

May we invite your enquiries ?

Adam machine equipment limited

4 GRANGE ST. · ST. ALBANS, HERTS · Tel: ST. ALBANS 56731/2

NUCLEAR CHEMICAL ENGINEERING

MANSON BENEDICT
Professor of Nuclear Engineering, Institute of Technology
THOMAS H. PIGFORD
Associate Professor of Nuclear Engineering, Massachusetts Institute of Technology

This book provides the first comprehensive treatment of the chemical engineering aspects of nuclear technology. It is intended for advanced and graduate students who have already taken courses in introductory nuclear engineering and reactor theory. Practising engineers will find it a useful work of reference as it summarizes most of the available information on chemical processes in nuclear technology, including that presented at the Geneva Conference in 1955.

The scientific and engineering principles behind separations are explained and combined with a description of the important materials and processes. The most important chapters cover isotope separations; they include unpublished methods for designing isotope separation plants and for estimating the change in composition and reactivity of nuclear fuels during irradiation. The sections dealing with properties and processing of materials after fission and irradiation will also interest many people. The earlier part of the book covers the concentration and purification of materials before they are used in nuclear reactors. Each chapter contains illustrative problems and references to other sources of related information.

September-October — *500 pages* — *71s 6d*

NUCLEAR ENGINEERING

edited by CHARLES F. BONILLA
Professor of Chemical Engineering, and Chairman of the Nuclear Engineering Committee, Columbia University; Consultant, Brookhaven National Laboratory

The purpose of this text and reference book is to give the basic principles of the twelve main engineering disciplines involved in the design of nuclear reactor cores and power plants. It is more detailed and extensive than previous books, especially on fluid flow, heat transfer, stress analysis and power cycles. The necessary background in nuclear physics and reactor physics is provided. All the material is entirely up-to-date and includes new developments in mathematical analysis of plastic flow in thermal stress; design of orifices for protection of parallel coolant channels; relative evaluation of fuel element shapes and coolants. Illustrations and advanced specific analyses make the book valuable to the working design engineer as well as to the student.

already published — *750 pages* — *94s*

NUCLEAR POWER ENGINEERING

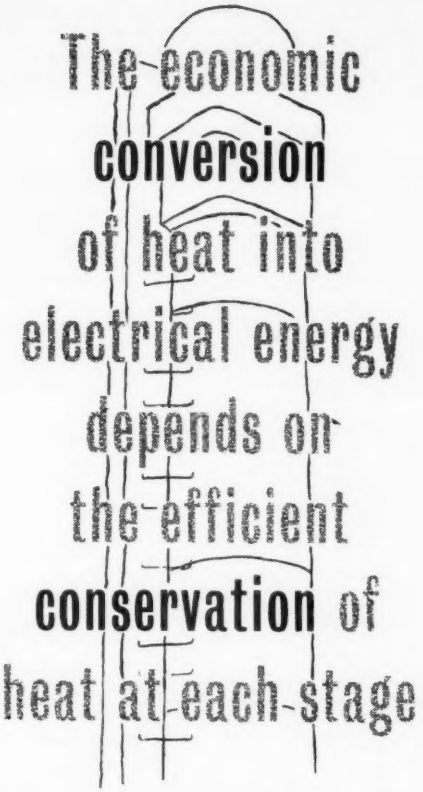
HENRY C. SCHWENK *Henry Pratt Company*
ROBERT H. SHANNON *United Engineers and Constructors Inc*
B. G. A. SKROTZKI *Management Editor, 'Power'*

This is a simple, concise treatment of a complex subject, it brings together in one compact volume all the essential facts about the design, construction and operation of nuclear power plants. Mechanical, electrical and power engineers or technicians will find it useful for individual study or as a textbook in introductory courses. It will also meet the needs of managers and executives concerned with the practical development of power stations.

already published — *250 pages* — *49s*

For further details please write:

McGRAW-HILL PUBLISHING COMPANY LTD
95 Farringdon Street
London EC4



The complexity of the heat handling problem in to-day's and tomorrow's nuclear power stations is one of the governing factors in the overall efficiency of the plant itself.

From the initial liberation of immense quantities of heat in the reactor, through each stage in the transfer and conversion of heat into electricity, it is of the utmost importance that heat losses by radiation and conduction be reduced to economic proportions. This aspect will be emphasised when the development of nuclear practice produces the higher operating temperatures now being demanded.

In supplying, from one source, a comprehensive range of thermal insulating and insulating refractory materials covering operating temperatures up to 1,370° C, Moler Products are contributing tangibly to the development of nuclear technology, while, at the same time, fully meeting the requirements of pulverised fuel fired power station boiler insulation. Full details of Fosalsil Insulating Bricks, M.P. Insulating Refractories (both in various grades) and the new Fosalsil Light weight Slab Insulation will gladly be supplied by our Technical Advisory Service.

HYTHE WORKS, COLCHESTER, ESSEX
Telephone: Colchester 3191 Telegrams: FURMOL COLCHESTER

NP4

M & W GRAZEBROOK DUDLEY WORCESTERSHIRE

LIMITED EST. 1750

Tel : DUDLEY 2431 - 3 Telegrams : GRAZEBROOK DUDLEY

MAKERS OF

HEAVY IRON CASTINGS UP TO 20 TONS

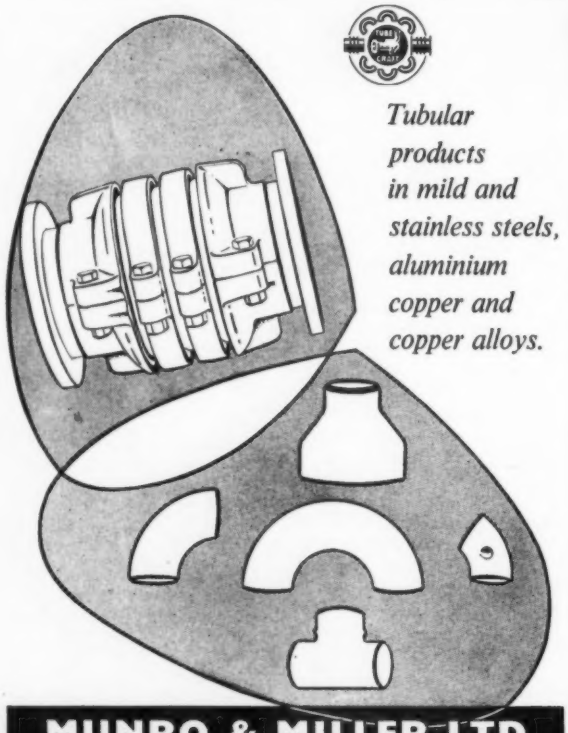
CLASS I VESSELS AND RAILWAY TANK WAGONS

STEEL FABRICATIONS FOR NUCLEAR POWER PLANT

STAINLESS STEEL AND ALUMINIUM PRESSURE VESSELS

HOT PRESSINGS UP TO 1½" THICK × 11 FT. DIA.

CHEMICAL PLANT HOMOGENEOUSLY LEAD LINED



Tubular products in mild and stainless steels, aluminium copper and copper alloys.

MUNRO & MILLER LTD

AFRICA HOUSE, KINGSWAY, LONDON, W.C.2

Telephone HOLBORN 5572 Telegrams "TUBECRAFT" LONDON

SCINTILLATORS

CRYSTALS

Anthracene and Stilbene in discs and cylinders.

PLASTIC

Naton 11—a new, high efficiency, glass clear scintillator.

N. 11 - X ray—a new, high efficiency, X ray scintillator.

LIQUID

Bottled or encapsulated ready for use.

or in "Scintipaks"—ready mixed for making up as required.

CHEMICALS

Highest scintillation quality for experimental work.

WRITE FOR FULL DETAILS TO

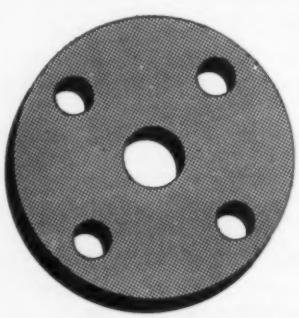
Nash and Thompson

Limited

OAKCROFT ROAD, CHESSINGTON, SURREY, ENGLAND.

Telephone : Elmbridge 5252 Pbx. Cables "Nashton" Chessington.

WHG/NT57



STAINLESS TUBES & FLANGES

We offer in approved grades of Stainless Steel

★ FLANGES MACHINED TO B.S. TABLES OR TO SPECIAL SIZES
★ SOLID DRAWN TUBES—FABRICATED PIPES
★ ROUND and HEXAGON BAR
★ PROFILES CUT TO ANY THICKNESS OR SIZE
★ CASTINGS TO CUSTOMERS SPECIFICATION

Keen Prices — Prompt Delivery

Send enquiries to Dept. N.P.

STAINLESS STEEL PROFILE CUTTERS LTD.

Farfac Works, Kings Grove, MAIDENHEAD. *'phone* 1522/23.

CLASSIFIED ADVERTISEMENTS

RATES	Classified advertisements are charged at 4s. per line. Semi-display setting £2 per single-column inch. 5% is allowed to trade advertisers for six insertions, 10% for 12 consecutive insertions. Box numbers will be charged 1s. extra
REMITTANCES	Cheques and postal orders should be sent to Rowse Muir Publications Ltd with the order for the advertisement
PRESS DAY	Advertisements must be received not later than October 14 for the November issue
TERMS	All advertisements are strictly net and must be prepaid
HEAD OFFICE	All advertisements should be addressed "Classified Advertising," NUCLEAR POWER, 3 Percy Street, London, W1
BOX OFFICE REPLIES	NUCLEAR POWER, 3 Percy Street, London, W1

SITUATIONS VACANT

THE NUCLEAR POWER PLANT CO. LTD.

A SENIOR ENGINEER

required

to be responsible for the design of H.V. and L.V. systems for Nuclear Power Stations at home and abroad.

The work will include the overall design and layout of these systems and the preparation of specifications for switchgear, transformers, motor starting equipment, protective gear cables, and control of alarm equipment.

Applicants should have a degree or equivalent qualification in Electrical Engineering, backed by no less than five years' practical experience in this field.

The successful candidate will work at Booths Hall, Knutsford, and if necessary, will be given assistance with house purchase.

Written applications giving full details of age, qualifications, and career to date to be sent to:

The Secretary,
The Nuclear Power Plant Co., Ltd.,
Booths Hall, Knutsford, Cheshire

Quoting reference NP/CRD/19.

THE NUCLEAR POWER PLANT CO. LTD.

requires

PHYSICISTS

for Expanding Programme on

REACTOR PHYSICS AND SHIELDING

The Company is engaged on the design and construction of Nuclear Power Stations for all parts of the world.

A competitive salary will be offered to the successful applicants, who will be required to work at Booths Hall, Knutsford.

Where necessary, deferment of National Service will be obtained and opportunity given for attending training courses in reactor technology.

Written applications with an accompanying sheet giving details of age, education, qualifications and career to date should be sent to

The Secretary,
The Nuclear Power Plant Co. Ltd.,
Booths Hall, Knutsford, Cheshire.

Please mark your envelope NP/NUC/20.

Applications are invited for the post of
DEPUTY DIVISION HEAD, ELECTRONICS DIVISION, ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

The Electronics Division has the tasks of studying problems involving electronic techniques, finding solutions to these problems, devising and supplying the necessary electronic apparatus and putting this apparatus into service The work covers very many aspects of nuclear energy, from field survey for uranium to gamma-ray spectrometry, from medical instruments to automatic computing devices.

The Deputy Division Head will play an important part in running the Division and will take charge of much of the electronic development and project work.

He should have a good general understanding of the scientific and engineering aspects of nuclear energy and be able to make critical assessments of requirements for electronic techniques and instruments in this field. A sound and up-to-date knowledge of electronic circuit techniques is required, together with experience of the problems involved in bringing electronic devices to the stage of small-scale production. Familiarity with the electronics industry is desirable.

He will be required to control scientific, technical, engineering and industrial staff and to supervise development and production contracts.

The salary offered will be in the range £2,100—£3,000.

Applications should be sent to Mr. K. H. B. Frere, Group Recruitment Officer, A.E.R.E., Harwell, Didcot, Berks, quoting ref. 935/202.

IF you are a 'born salesman' preferably with experience in the fields of atomics, electronics and instrumentation, there is an opportunity with an old established company with modern ideas in export sales promotion. Potential earnings can be in the £3,000 bracket. Successful applicant would be considered for Directorship. Top grade salesmen are invited to send fullest particulars which will be treated in strict confidence to: U.K.A.P. C/o D. J. Keymer & Co Ltd, 52 Bedford Row, London, WC1.

SITUATIONS VACANT *cont.*

PLESSEY NUCLEONICS LTD. have a vacancy for a PHYSICIST to carry out original work on radiation detection devices. Applicants should possess a degree in Physics and could have an interest in mathematical physics. Alternatively, an interest in the application of electronics to reactor instrumentation and control or in the field of reactor physics would be desirable.

A generous salary will be offered, based upon qualifications and previous experience. Please write in confidence giving full details to The Chief Engineer, Plessey Nucleonics Ltd., Weedon Road, Northampton.

BEXFORD LTD.,

Brantham, nr. Manningtree, Essex

have vacancies for

PHYSICISTS

Since 1946, BEXFORD LIMITED, in an entirely new factory, has established the manufacture of photographic film base in this country. This successful enterprise is the only one of its kind in the British Commonwealth.

The Factory and Research Laboratories form an attractive modern layout and are situated in pleasant country on the Essex-Suffolk border, only a few miles from the sea.

To meet expanding demands the company is extending its factory and building a new wing to the laboratory. The laboratories are equipped with the most modern apparatus, and the development of new techniques is encouraged.

Physicists are required for investigations into the manipulation of cellulosic and synthetic film forming materials and into fundamental studies of the relationship between process variables and film structure and properties.

Applicants should have good honours degrees. Previous industrial experience, particularly in the plastics field, would be an advantage, but is not essential. Prospects are excellent and salaries, depending on age and experience, compare favourably with any offered. Facilities are available for assisted house purchase if required.

Apply in writing to the Technical Director, BEXFORD LIMITED, Brantham, Manningtree, Essex.

SCIENTISTS AND TECHNOLOGISTS in industry are eligible for membership of the ASSOCIATION OF SCIENTIFIC WORKERS, an Association which gives a trade union service and seeks by all means to raise the status of scientific work. Details from the General Secretary, 15 Half Moon Street, Piccadilly, London, W.1.

SPECTROGRAPHER required for Applied Research Laboratories European Office, Lausanne, Switzerland. Salary, £1,000—£1,200 per annum plus £200 cost-of-living allowance. Applicants should have experience in the development of methods for ferrous and non-ferrous materials, and in the statistical interpretation of experimental results, together with some acquaintance with the principles involved in direct-reading analysis, vacuum spectroscopy and X-ray fluorescence analysis. Age preferably 25-35. Applications should be made to APPLIED RESEARCH LABORATORIES (G.B.) LIMITED, 69a Victoria Street, St. Albans, Herts.

A SENIOR DEVELOPMENT

ENGINEER

for work on

NUCLEAR

INSTRUMENTATION

(For the Berkeley Power

Reactors and several Research

Reactors)

is required by

SUNVIC CONTROLS

LIMITED

The Company is at present providing instruments for the BERKELEY Power Reactor and several research reactors and the successful applicant will be concerned with this development and will be required to participate in field trials. This appointment will be of interest to Graduates in Physics or Electrical Engineering who have had good experience on electronic instruments for nuclear work. The appointment will carry the responsibility for leading a small team of development engineers concerned with the detailed circuit design of electronic instruments for nuclear reactors, including the construction and testing of experimental equipment up to the prototype stage.

The Company's policy is to provide every facility for development work, and individual conditions include:

Fully commensurate salary and pension rights;
Housing for rental or house purchase assistance.

We shall be pleased to discuss this appointment on an informal basis, and in absolute confidence, with all suitably qualified applicants.

For further particulars, please apply to:—Personnel Officer, SUNVIC CONTROLS LTD., Harlow Essex. (Tel.: Harlow 24231.)

ELECTRONIC ENGINEERS required for the Technical Advisory Laboratory of Design Department. The work is varied and interesting, involving practical research into the suitability of all components and materials for inclusion in new designs of receivers, also investigations of oscillator stability, temperature measurements and compensation, etc., of prototype television and radio receivers, including special requirements for export equipment, etc., etc.

Two vacancies exist: (a) for a SENIOR ENGINEER having H.N.C. or equivalent qualifications and some experience in the above work, and (b) for an ASSISTANT ENGINEER having O.N.C. or equivalent qualifications.

Welwyn Garden City is well situated in pleasant countryside within easy reach of London, and applicants from the London area would become eligible for housing.

Applications, giving full details of experience, age, qualifications, salary expected, should be forwarded initially to Personnel Department (R.11), MURPHY RADIO LIMITED, Welwyn Garden City, Herts.

SUB-CONTRACTING

CAPACITY AVAILABLE for Plate and Sheet Metal Fabrication, General Machining and Erection, Special Machines and Prototypes to Customers' designs. Hobbs, Hart and Co Ltd (Telephone Leytonstone 1034).

CAST F.D.P. STAINLESS STEEL GLOBE GATE & CHECK VALVES 600 lb. WP., flanged ends. Full particulars upon application. Write to Foster Wheeler Ltd., Foster Wheeler House, 5 Ixworth Place, London, S.W.5.

INTRICATE PROTOTYPE WORK, jig boring, grinding, etc. Quick delivery, A.I.D. Write for plant list, Porter Prototype Engineering Co., Augusta St., Birmingham, 18.

PUBLICATIONS

THE NUCLEAR POWER YEAR BOOK and BUYERS GUIDE — the indispensable reference work — is now available. Copies can be ordered, U.K.: price 42/- plus 1/- postage and packing. Overseas: price 63/- plus 1/6 postage and packing. US, Canada: price $8 plus 50c postage and packing, from Rowse Muir Publications Ltd, 3 Percy Street, London, W1

EXTRA COPIES of DATA SHEETS and REACTOR DRAWINGS published in NUCLEAR POWER can be obtained price 6d. each and reprints of the large full colour (36″×24″) Berkeley, Bradwell, Dounreay and RWE Supplements, 2/- each post free from Rowse Muir Publications Ltd, 3 Percy Street, London, W1.

U.K.A.E.A.

SENIOR ENGINEERING APPOINTMENTS

The Industrial Group of

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

has vacancies for

DEPUTY CHIEF ENGINEERS

and

ASSISTANT CHIEF ENGINEERS

in the Design Offices of the Engineering Branch at Risley, near Warrington, Lancashire

The Industrial Group, in collaboration with Harwell, is engaged upon a large scale programme connected with the industrial applications of nuclear energy, involving the design and construction of nuclear reactors and their associated processing plants. Much of the work is of a pioneering nature and the emphasis is on developing advanced types of reactors which will enable the United Kingdom to maintain the position it holds today in the field of nuclear power.

Each Design Office, which is headed by a Chief Engineer, has an overall responsibility normally for one such project at a time. Designs are made in close collaboration with research and development groups and assistance is given by specialised engineering and commercial offices. Design offices maintain close contact with manufacture and site construction.

Within each Design Office, Deputy and Assistant Chief Engineers are responsible to a Chief Engineer for the whole range of duties covering specific parts of a project.

Applicants should be corporate members of a Senior Engineering Institution or possess an honours degree in mechanical or chemical engineering and have served a recognised engineering apprenticeship. Previous experience of nuclear engineering is not essential and a sound training in mechanical or chemical engineering with experience of high quality design work should enable an engineer quickly to take an effective part in the work. An initial period will be allowed for successful candidates to obtain a thorough understanding of the work done by the Industrial Group.

Commencing salaries for these posts will be:-

Deputy Chief Engineer ... ... not less than £2,600

Assistant Chief Engineer ... ... not less than £2,100

The posts are permanent and pensionable. Housing should be available within a reasonable time.

If necessary, informal interviews with a senior engineer of the Authority may be arranged for suitably qualified candidates who may wish to learn more of the nature of the work before making formal application for appointment.

Apply in the first instance to:

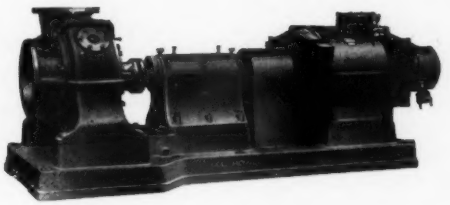
CHIEF RECRUITMENT OFFICER

U.K.A.E.A.

INDUSTRIAL GROUP HEADQUARTERS, RISLEY, WARRINGTON, LANCS.

Please quote reference: 2042

SLURRY PUMPS



LEE, HOWL & CO., LTD.

TIPTON, STAFFS.

Welcome enquiries for

PUMPS

FOR ALL DUTIES

LONDON OFFICE:

375A REGENTS PARK ROAD, FINCHLEY, N.3

NUCLEAR ENERGY PROJECTS

The opportunity to work on control and instrumentation problems of Nuclear Reactors including those for

NUCLEAR POWER STATIONS

and

H.M.S. " DREADNOUGHT "

is provided by vacancies in the NUCLEAR DIVISION of ELLIOTT BROTHERS (LONDON) LIMITED.

Vacancies exist for:—

(a) A Senior Physicist

(b) A Senior Electronic Engineer

The scope of the work covers the development of Radiation Measuring devices and Electronic, Transistor and Magnetic Amplifier circuits for measurement and control applications.
Qualifications must include for (a) an Honours Degree in Physics and experience of radiation measuring techniques; and for (b) education or training to Degree standard and some years' experience in the development of electronic and servo control equipment, not necessarily for nuclear applications.
Considerable opportunities for advancement are offered. The work is interesting and varied, and is concerned with important and realistic projects.
Apply, giving full details of background and qualifications, to Personnel Officer, Century Works, Conington Road, Lewisham, S.E.13.

INDEX TO ADVERTISERS

ACF Industries Inc A37
Acheson Colloids Ltd A32
Acton, G A106
Adam Machine Equipment Ltd A136
Adcola Products Ltd A104
AEI—John Thompson Nuclear Energy Co Ltd Jul
Aerox Ltd Sep
Air Control Installations Ltd A29
Allen, P. W. & C Mar
Amal Ltd Sep
Appleby & Ireland Ltd A17
Armstrong Whitworth Aircraft, Sir W. G. A133
Associated Lead Manufacturers Ltd A6
Atlas Steel Foundry & Engineering Co Ltd 396
Atomwirtschaft Apr
Avica Equipment Ltd A11
Ayrshire Dockyard Co Ltd, The A28

Backer Electric Co Ltd A80
Bailey Meters & Controls Ltd May
Bailey, N. G. & Co Ltd A41
Baldwin Instrument Co Ltd Sep
Balfour, Beatty & Co Ltd Apr
Barnet Instruments Ltd May
Berk, F. W. & Co Ltd Schori Division Jan
Birfield Industries Ltd A13
Birmingham Battery & Metal Co Ltd, The A69
BKL Alloys Ltd A101
Blagdon Engineering Co Ltd A98
Blakeborough, J. & Sons Ltd May
BMB (Sales) Ltd Aug
Board of Trade Feb
Boby, William & Co Ltd A66
Brackett, F. W. & Co Ltd A96
Bridges, F. W. & Sons Ltd Aug
British Atomic News Ltd A32
British Ermeto Corp. Ltd A98
British Jeffrey-Diamond Ltd A20
British LaBour Pump Co Ltd Jul
British Olivetti Ltd Sep
British Oxygen Gases Ltd Sep
British Thomson-Houston Co Ltd, The Apr
Broads Mfg Co Ltd A84
Brooker, W. J. Ltd Sep
Brookhirst Switchgear Ltd A109
Brown, E. G. & Co Ltd A120
Bryce Electrical Construction Co Ltd Mar
Burndept Ltd Sep
Butterfield, W. P. Ltd Sep

Cambridge Instrument Co Ltd A20
Cape Asbestos Co Ltd, The A9
Carbon Dioxide Co Ltd, The Mar
Cargoaire Ltd Sep
Carruthers, J. H. & Co Ltd A42
Carter, B. F. & Co Ltd Feb
Cementation Co Ltd, The A110
Central Electricity Authority A73
Chance-Pilkington Optical Works Sep
Chemical & Insulating Co Ltd Jun
Chichester Rubber Co Ltd, The Apr
Cinema-Television Ltd Aug
Clarke, Chapman & Co Ltd A44
Clay Cross (Iron & Foundries) Ltd A105
Clyde Crane & Booth Ltd A95
Cockburns Ltd Mar
Copes Regulators Ltd A106
Cossor Instruments Ltd Jun
Courtburn Positioners Ltd A22
Craig & Derricott Ltd A108
Crossley Bros Ltd A68

Darham Industries (London) Ltd A112
Darlington Insulation Co Ltd Jul
Davenport Engineering Co Ltd Aug
Davey, Paxman & Co Ltd A92
Davidson & Co Ltd A97
Dependable Relay Co A126
Dickens, Stuart B. Ltd A113
Doulton Industrial Porcelains Ltd A98
Dowty Nucleonics Ltd A35
Dowty Seals Ltd Sep
Dynatron Radio Ltd Sep

Ekco Electronics Ltd Sep
Electric Furnace Co Ltd Apr
Electro-Hydraulics Ltd A136
Electrothermal Engineering Ltd Jul
Elliott Bros (London) Ltd A141
Endecotts (Filters) Ltd A134
Energia Nucleare A135
English Electric Co Ltd, The A128-129
Erhard, Johannes A12
Ericsson Telephones Ltd Aug
Evans, J & Son (Portsmouth) Ltd A26
Evers, D. H. Insurance Sep
Extrudex Ltd A120

Farr, Edward Ltd A102
Fielden Electronics Ltd A134
Fielding & Platt Ltd A119
Findlay, Alex & Co Ltd A45
Firkins, G. & A. Ltd Sep
Firth, Thos. & John Brown Ltd A70
Firth-Vickers Stainless Steels Ltd A111
Fisher & Ludlow Ltd Aug
Fleming Radio (Developments) Ltd Jun
Fluidrive Engineering Co Ltd A102
Forster, J. S. & Co Ltd A88
Fraser & Fraser Ltd A134
Fulmer Research Ltd May

Gardner, Henry & Co Ltd Sep
Gardners Radio A130
General Electric Co Ltd A27
General Radiological Ltd A99
Glenfield & Kennedy Ltd Jun
Gordon, James & Co Ltd A122
Graviner Manufacturing Co Ltd A16
Grazebrook, M. & M. Ltd A138
Grindlay, J. & Co Ltd Jun
Gwynnes Pumps Ltd Jul

Hanovia Jun
Hargreaves, Henry & Sons Ltd Jun
Harland Engineering Co Ltd, The A81
Harvey, G. A. & Co (London) Ltd A65
Haworth, F. (ARC) Ltd Jul
Hayward Tyler & Co Ltd Sep
Head Wrightson & Co Ltd A46
Heather Filters Ltd Sep
Hewell Spring Co Ltd A98
Hick Hargreaves & Co Ltd A100
High-Pressure Components Ltd Sep
Highfield Gear & Engineering Co Ltd A118
Hilger & Watts Ltd Sep
Hills (West Bromwich) Ltd A25
Hobson, H. M. Aug
Holland, B. A. & Co Ltd, The A126
Holiday Hall & Stinson Ltd A82
Honeywell-Brown Ltd Sep
Howden, James & Co Ltd Sep
Humphreys & Glasgow Ltd A31

Ide, C. F. Engineering Ltd A136
Imperial Chemical Industries Ltd A38
Imperial Chemical Industries (Metals) Ltd Cover 2
Industrial Exhibitions Ltd May
Industrial First Aid Supplies Ltd A106
Intermit Ltd A40
Isotope Developments Ltd A18
IV Pressure Controllers Ltd Jul

Jenkinson, W. G. Ltd A132
Johnstone, Archibald Ltd Mar

KDG Instruments Ltd Jun
Keith Blackman Ltd A127
Kelvin & Hughes (Marine) Ltd A78
Kennedy, Allan & Co Ltd A14
Kenyon, William & Co Ltd Sep
Kodak Ltd A4

Nuclear Power

is the world's leading nuclear journal — the most influential and widely read

Labgear (Cambridge) Ltd A34
Laboratory Apparatus & Glassblowing Co Apr
Laing, John & Son Ltd Apr
Lake & Elliot Ltd Aug
Lawrie, J. & T. Ltd Sep
Lee, Howl & Co Ltd A141
Lenanton, John & Sons Ltd A82
Lloyd, F. H. & Co Ltd A89
Lyons, Claude Ltd Mar

McAlpine, Sir Robert & Sons Ltd A47
McGraw-Hill Publishing Co Ltd A137
Madan, Charles S. & Co Ltd Sep
Magnetic Valve Co Ltd A30
Mallinson, William & Sons Ltd Sep
Mancuna Engineering Co Ltd, The Sep
Marston Excelsior Ltd Sep
Martonair Ltd A130
Mason, E. N. & Sons Ltd A131
Mather & Platt Ltd A72
Matthews, D. & Son Ltd A80
MB Dredging Co Ltd A84
MB Metals Ltd Aug
Mervyn Instruments A94
Metropolitan-Vickers Electrical Co Ltd Cover 3
Miller, P. & L. Ltd Sep
Mills Scaffold Co Ltd Jul
Mirrlees, Bickerton & Day Ltd A3
Mitchell Engineering Ltd Jul
Moler Products Ltd A137
Molart Engineeering Co Ltd Sep
Moore, W. & E. Ltd A100
Morgan Crucible Co Ltd, The A18
Mountford, Fredk (Birmingham) Ltd A24
Mullard Ltd May
Mullard X-Ray Division Jul
Munro & Miller Ltd A138
Murex Ltd A22
Murex Welding Processes Ltd A33

Nash & Thompson Ltd A138
North British Chemical Co Ltd Aug
Norton, F. A. & Sons Ltd A86
Nuclear Enterprises (GB) Ltd Sep
Nuclear Graphite Ltd Apr
Nuclear Power Plant Co Ltd, The Cover 1

Ozonair Engineering Co Ltd Aug

Palatine Tool & Engineering Co (Surbiton) Ltd Sep
Panax Equipment Ltd Aug
Pantak Ltd A116
Parsons, C. A. & Co Ltd A48
Parsons, Sir Howard Grubb & Co Ltd A93
Pascall Engineering Co Ltd, The Sep
Paterson Hughes Engineering Co Ltd A5
Peabody Ltd Aug
Pearson, T. B. & Sons Ltd A103
Peters & Barham Ltd A104
Philips Electrical Ltd A1
Powell Duffryn Carbon Products Ltd A10
Premier Cooler & Engineering Co Ltd Aug
Pulsometer Engineering Co Ltd May
Pye Ltd (Industrial TV Division) Apr
Pyrene Co Ltd, The Apr
Pyrotenax Ltd A92

Racal Engineering Ltd Sep
Rawlplug Co Ltd, The A21
Raytheon Manufacturing Co Apr
RFD Co Ltd (Industrial Safety Division) Aug
Rockweld Ltd Aug
Rocol Ltd A19
Ross, Donald & Partners Ltd A91
Royal Photographic Society, The May
Rubery Owen & Co Ltd A122

Sadd, John & Sons Ltd A108
Sangamo Weston Ltd A24
Sankey, Joseph & Sons Ltd A90
Savage & Parsons Ltd Aug
Shandon Scientific Co Ltd Feb
Shaw-Petrie Ltd A8
Shell Chemical Co Ltd Feb
Shell Mex & BP Ltd A76
Shelton Iron & Steel Ltd A104
Sigmund Pumps Ltd A85
Silica Gel Ltd May
Simmonds, L. E. Ltd A26
Simon Carves Ltd A36
Simplifix Couplings Ltd A133
Skinningrove Iron Co Ltd A112
Smith, J. & Sons (Clerkenwell) Ltd A30
Smith, W. H. & Co Electrical Eng Ltd A94
Solartron Electronic Group Ltd, The Sep
Solus-Schall Ltd A135
Southern Instruments Ltd A121
Spencer Chapman & Messel Ltd Sep
Sperry Gyroscope Co Ltd A115
Spun Concrete Ltd A114
Stainless Equipment Co Ltd A134
Stainless Steel Profile Cutters Ltd A138
Staveley Iron & Chemical Co Ltd, The A106
Steven, A. & P. Ltd May
Stewart Aeronautical Supply Co Ltd Aug
Sturtevant Engineering Co Ltd Aug
Suffolk Iron Foundry (1920) Ltd A136
Sunvic Controls Ltd Sep

Talbot Stead Tube Co Ltd A74-75
Teddington Aircraft Controls Ltd A23
Terrapin Ltd A82
Thermocontrol Inst. Co Ltd A96
Thompson, John Ltd Cver 4
Thorn Electrical Industries Ltd Aug
Tileman & Co Ltd Jun
TL Nuclear Engineering Ltd Aug
Timeg Ltd Aug
Tipple, W. & C. Ltd A104
Titanium Metal & Alloys Ltd Apr
Trollope & Colls Ltd Jul
Tudor Accumulator Co Ltd, The A107
Turbine Gears Ltd Jun
Turners Film Unit A26

UKAEA A141
Unit Superheater & Pipe Co Ltd A67
United Air Coil Ltd Aug

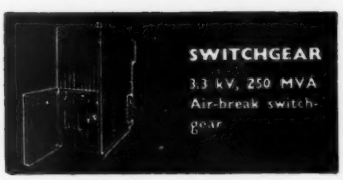
Varatio-Strateline Gears Ltd A86
Vacu-Blast Ltd Jun
Vokes Genspring Ltd A71

Wakefield-Dick Industrial Oils Ltd A79
Wallace & Tiernan Ltd A90
Wandleside Cable Works Ltd A123
Ward, Thos. W. Ltd Jun
Weatherfoil Heating Systems Ltd Aug
Weir, G. & J. Ltd A7
Welford Gravels Ltd A88
Western Detail Manufacturers Ltd A39
Wharton Crane & Hoist Co Ltd A15
Whatlings Ltd Jun
Whessoe Ltd Jan
Whipp & Bourne Ltd A116
Willan, G. L. Ltd Sep
Wilson, A. C. & Partners Ltd A132
Wolf Electric Tools Ltd Jun
Wright Anderson & Co Ltd A117

Yarrow & Co Ltd A102
Yorkshire Copper Works Ltd, The A87

NUCLEAR POWER is published by Rowse Muir Publications Ltd, 3 Percy Street, London, W1, England, and printed by The Haycock Press, Ltd, SE5

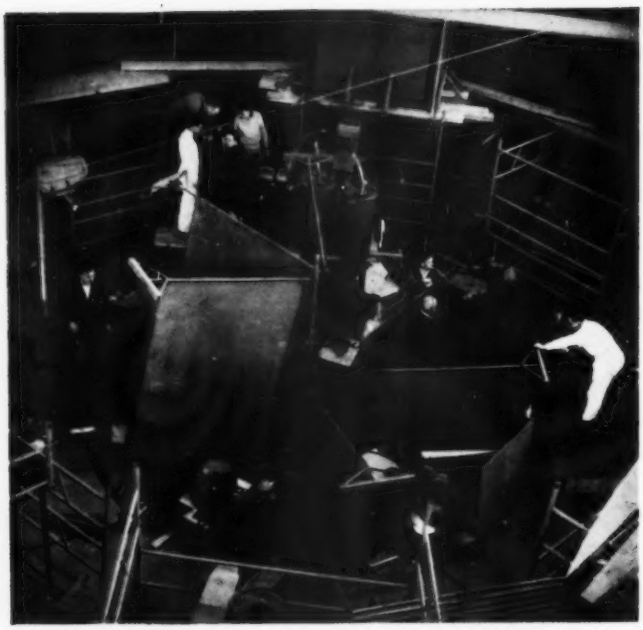
IN POWER STATIONS, as in every sphere of industry, the results of Metropolitan Vickers research, enterprise, and experience are clearly evident. Many advances in the design of equipment for power stations owe their origin to this great organisation.



METROPOLITAN-VICKERS
ELECTRICAL CO LTD · TRAFFORD PARK MANCHESTER, 17

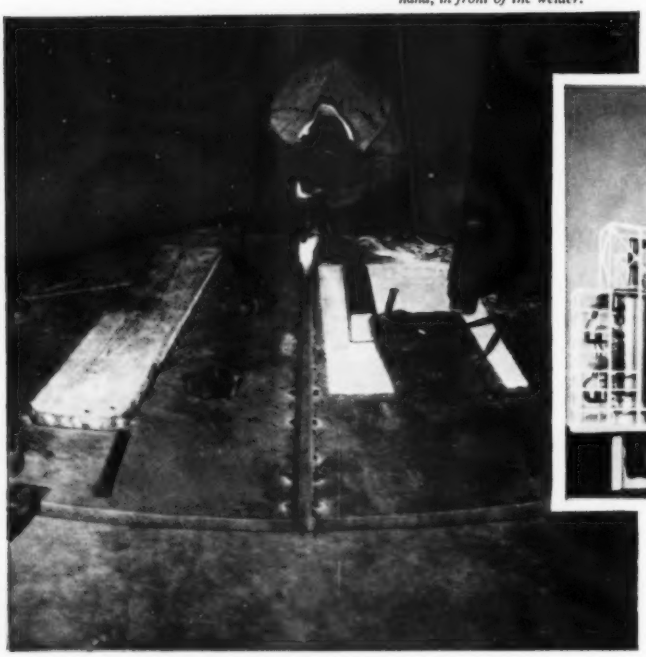
An A.E.I. Company

Nuclear Power
THE JOURNAL OF BRITISH NUCLEAR ENGINEERING



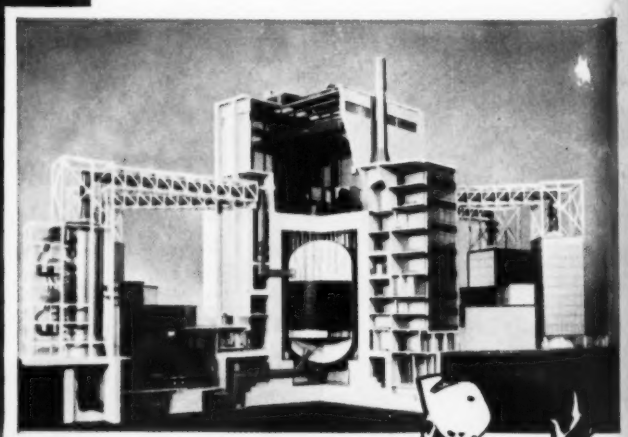
Welding begins inside the bowl of the reactor vessel. Six teams of John Thompson welders work outwards from the centre, welding the 3in. thick steel plates which have been assembled and are temporarily held in position by clamps. Further welding teams began working on the next ring of plates shortly after this photograph was taken. In the background, an X-ray unit stands ready inside the bowl for weld examination.

A welder works from the bottom centre of the reactor vessel, welding together the 3in. thick 'petal' plates which form the lower bowl. Accurate edge preparation of the plates has been achieved by a specially developed flame planing technique in John Thompson's works. The temperature of the weld area is maintained between welding runs by means of flame torches, one of which is seen ready to hand, in front of the welder.

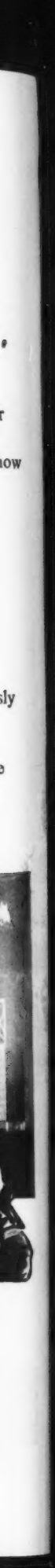


Buttercups at Berkeley...

John Thompson's construction men — familiar in their yellow helmets on power station and industrial sites throughout Britain — are now at work on the Central Electricity Authority's first commercial nuclear power station being built by the A.E.I. — John Thompson Nuclear Energy Company at Berkeley, Gloucestershire. Crisply, the construction programme proceeds to a minutely planned schedule. The bottom dome portion of one of the huge 1,000 ton reactor vessels was transported in sections to the site where it is being welded together to grow simultaneously with the reactor building. The "Buttercups" are speedily getting on with this job in which they are building the reactor vessels, the thermal shielding, the sixteen large heat exchange towers, gas ducting and nuclear fuel loading machines.



JOHN THOMPSON GROUP

JOHN THOMPSON LIMITED

JOHN THOMPSON LIMITED · WOLVERHAMPTON · ENGLAND